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ABSTRACT

This study investigated the relationship among personality types, cognitive preference orientation, science achievement, intelligence, attitudes toward science and scientists, sex, and geographic area of eighth-grade science students using the following four instruments: (1) Myers-Briggs Type Indication (MBTI): (2) Cognitive Preference Examination II (CPE-II): (3) Science and Scientists Attitude Inventory (SASAI): and (4) Science Knowledge Test (SKT). The sample included 153 males and 130 females from urban, suburban, and rural locations. The MBTI results classified students according to the following dichotomies: extrovert-introvert, sensing-intuitive, thinking-feeling, and judging-perceiving. Cognitive preference groupings by a single preference resulted in memory, application, questioning and no preference categories, while grouping by two preferences resulted in memory-application, memory-questioning, application-questioning, and no preference categories. The investigation tested fourteen hypotheses. The relationship between MBTI sensing and intuitive types (in favor of intuitives) and between MBTI judging and perceiving types (in favor of perceiving) had a statistically significant relationship to intelligence. Statistical significance also existed between intelligence and attitudes toward science (but not scientists), and between science achievement and attitudes toward both science and scientists. The relationships of the other variables investigated did not yield significant results at the .001 level. (Author/GS)

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INVESTIGATION OF THE RELATIONSHIPS BETWEEN PERSONALITY TYPES OF EIGHTH-GRADE SCIENCE STUDENTS AND COGNITIVE PREFERENCE ORIENTATION

by

John Anthony Novak

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Education)
in The University of Michigan
1980

Doctoral Committee:

Professor Burton E. Voss, Chairman
Professor Carl F. Berger
Professor James J. Duderstadt
Associate Professor Herbert J. Eibler
Professor M. Clemens Johnson

SE 033 241

ABSTRACT

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John Anthony Novak

Chairman: Burton E. Voss

The purpose of this study was to determine relationships among the MBTI personality types, cognitive preference orientation, science achievement, intelligence, attitudes toward science and scientists, sex and geographic area of eighth-grade science students.

Data were collected during May 1979 from 283 (153 male and 130 female) eighth-grade science students in urban (middle), suburban (junior high) and rural (middle) schools. Four instruments were used to collect the data:

1. Myers-Briggs Type Indication (MBTI)
2. Cognitive Preference Examination II (CPE-II)
3. Science and Scientists Attitude Inventory (SASAI)
4. Science Knowledge Test (SKT)

The MBTI results classified students in this study into the following types: 56.5% extravert to 63.5% introvert; 64.2% sensing to 35.8% intuitive; 33.6% thinking to 66.4% feeling; 36.5% judging to 63.5% perceiving. Chi-square analyses indicated that the type distribution of the students in this study was not significantly different (α=.05) from the type distribution in

D. C. May's 1971 Florida eighth-grade junior high school sample.

The cognitive preference orientation results classified 278 students in this study into the following groups based on a single preference: 5.0% memory; 12.3% application; 3.6% questioning; 79.1% no detectable preference. When classified according to two preferences, 230 students were grouped as follows: 40.3% memory/application; 20.8% memory/questioning; 21.6% application/questioning; 17.3% no detectable preference.

Fourteen hypotheses were tested at $\alpha=.001$ to answer eight questions proposed in the study. The prediction that MBTI introvert-intuitive-thinking-perceiving types would prefer a questioning, application or application/questioning cognitive preference orientation and that MBTI extravert-sensing-feeling-judging types would prefer a memory, memory/application or memory/questioning cognitive preference orientation was not supported by statistical analysis.

Statistically significant differences in intelligence were found between MBTI sensing and intuitive types (in favor of intuitives) and between MBTI judging and perceiving types (in favor of perceiving types).

A statistically significant relationship was found between intelligence and attitudes toward science (but not toward scientists). Statistically significant

relationships were also found between science achievement and attitudes toward both science and scientists.

Statistically significant relationships were not found among the following variables: MBTI personality types and cognitive preference orientation, science achievement, attitudes toward science and scientists, sex of students, and geographic area; cognitive preference orientation and ingelligence, science achievement, sex of students, and geographic area; attitudes toward science and scientists, and sex of students and geographic area.

A composite picture of the students in this study revealed them to be similar on most measures examined. However, it was suggested that teachers consider personality factors and cognitive preference orientation when planning for the instruction of students, particularly for the large percentage of students who do not exhibit a definite cognitive preference orientation. It was also suggested that research efforts be focused on an examination of those factors which may influence the direction the cognitive preference orientation of these students takes.

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DEDICATION

To my mother,

Jennie Novak

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Many individuals have helped in the realization of this doctoral study. They have given their time, talents and understanding to make an idea a reality. Among them were:

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CHAPTER I

INTRODUCTION

Background of the Study

Cognitive Preferences

Research has been done in science education comparing traditional science programs to one of the curriculum projects developed during the 1960's. These curriculum projects emphasized intellectual processes, fundamental principles of the disciplines (i.e., structure), and the understanding of key concepts. Rather than presenting students with a survey of known information (characteristic of the traditional classes), the projects attempted to teach them how to acquire, evaluate and retrieve knowledge in a given field, i.e., to teach them how to inquire (Heath, 1964).

Research priorities have shifted from the comparative studies of the 60's to studies involving selected antecedents (entry conditions), transactions (interactions) and outcomes (results of instruction) of science education (Yager, 1978). Nevertheless, the fact remains that the comparative studies were necessary to determine the objectives of the various curriculum projects. These objectives were usually measured by tests requiring students to demonstrate knowledge of facts and terms,

to apply this information and to demonstrate comprehension of organizing schemes.

The results of numerous comparative studies were reviewed by Ramsey and Howe (1969). They pointed out that "... students in newer course improvement projects achieve[d] at least as much traditional content as do [did] students in conventional courses and achieve[d] more in the content area defined by the new course" (Ramsey and Howe, 1969, p. 18). This statement was not too surprising when the objectives of both types of classes were examined. Students in both classes were asked to learn the basic facts and ideas of the courses, together with pertinent applications and basic organizing schemes.

However, Ramsey and Howe (1969) indicated that curriculum projects were also characterized by outcomes other than acquiring knowledge, such as the development of critical thinking, understanding the scientific enterprise and the development of positive attitudes, among others. These outcomes depended not only on the objectives of the course, but also on such variables as: teacher characteristics (open, indirect behaviors versus fact-centered, direct behaviors); the background and philosophy of the teacher; instructional strategies; type of classroom; and student characteristics.

Since the goals of the curriculum projects were

different from the goals of the traditional courses of instruction, Heath (1964) proposed an alternative approach to evaluating their effectiveness, i.e., to determine outcomes other than acquiring knowledge. According to Heath,

> The interest is not in whether the student can identify correct and incorrect information but rather what he is to do with information intellectually. If a goal of instruction is to change the student's intellectual style within some acaemic subject, a test of such "achievement" must permit him to exhibit some preference in cognition. (Heath, 1964, p. 241)

Heath (1964) defined these differing modes of attending to the subject matter of a particular course as cognitive preferences.

Heath (1964) designed a cognitive preference test (CPT) to evaluate the effectiveness of one particular curriculum project, namely, PSSC physics. Each test item consisted of a stem followed by four equally correct responses. One response was designed to show a preference for the memory of specific facts or terms (M). Another response involved the application of information given in the stem (A). A third response reflected some challenging or questioning of the basic information (Q), and the fourth response was a statement of a fundamental principle (P). The following example is illustrative of a cognitive preference test item:

The pressure of a gas is directly proportional to its absolute temperature. [Stem]

A) The statement, as given above, fails to consider the effects of volume changes and changes of state. [Questioning-Q]

B) Charles' or Gay-Lussac's Law. [Memory-M]

C) The statement implies a lower limit to temperature. [Principle-P]

D) This principle is related to the fact that overheated automobile tires may "blow out." [Application-A]

(Heath, 1964, p. 243)

One objective of Heath's (1964) CPT was to determine if the cognitive preference orientation of students in PSSC physics differed from that of students in traditional physics classes. Heath (1964) postulated that a strong preference for Q-P would be characteristic of the inquiry-learning associated with PSSC physics, whereas a strong preference for M-A would be characteristic of students in a traditionally-oriented physics class. Since PSSC physics students exhibited a stronger preference for Q-P than students in a traditional physics class, and the traditional students exhibited a stronger preference for M-A than PSSC physics students, he concluded that one of the goals of PSSC physics was being achieved.

Heath (1964) proposed cognitive preference testing as a means to determine if the goals of curriculum projects were being achieved. In addition, cognitive preference testing offers another promising use, namely,

as a potential means of identifying the intellectual or cognitive styles of students. Heller (1977) has defined cognitive style as "a stable way an individual organizes and perceives his environment and processes information" (p. 10).

Williams (1975) has pointed out that it is "... meaningful to conceptualize cognitive styles as stable preferences which manifest themselves in and affect abilities ..." He views cognitive preferences as one dimension of cognitive style, defining them "... as the characteristic way in which persons prefer to conceptualize and organize the stimulus world" (p. 61).

Williams (1975) has reviewed other dimensions of cognitive style that can be measured: field-independence-dependence; leveling-sharpening; category width; equivalence range; analytic cognitive style; conceptual vs. perceptual motor dominance; and strong vs. weak automatization. These dimensions are usually measured by abstract instruments, such as the Embedded Figures Test for field-independence-dependence.

However, Williams (1975) has pointed out that,

> If the concept of cognitive styles is to prove useful in an educational context, either by contributing to the prediction of success in various disciplines, or to the development of appropriate teaching methods, then it will be necessary to show a relationship between cognitive style dimensions and performance on academic tests. (p. 62)

The cognitive preference orientation of students would represent one dimension of their cognitive style that could be measured by performance on an academic test.

Kempa and Dubé (1973) have indicated that,

> The identification and effective measurement of these styles, used in addition to the grades derived from normal cognitive tests, could lead to a more valid and comprehensive characterisation of students' overall educational attainment than results from academic achievement alone.
> (p. 280)

In addition, knowledge of cognitive styles "... may provide a basis of adjusting instructional strategies to the learning characteristics of individuals" (Kempa and Dubé, 1973, p. 279).

An examination of those factors influencing the process of inquiry should be investigated if one of the goals of science education is to produce inquiry-oriented, scientifically literate citizens. Gagné (1963) has indicated that many courses,

> ... seem to be neglecting the student in the most important sense that they do not encourage him to acquire the attitudes of enquiry, the methods of enquiry, the understanding of enquiry. They provide him with a great many facts, with knowledge of important principles, even with the capability of using previously discovered principles in situations novel to him. But they omit this essential part of his education as a scientist, or even as an informed citizen, by not establishing within him the disposition which makes him able to employ enquiry in the manner so well known to scientists.
> (p. 144)

Heath (1964) indicated that one of the goals of the curriculum projects was to teach students the inquiry method, i.e., how to acquire, evaluate and retrieve knowledge in a given field. Voss (1968) succinctly defines inquiry "... as a search for information, or knowledge or truth" (p. 9). Although inquiry strategies are not limited to the following, they would certainly include the ability to ask relevant questions, to challenge data and to develop "... the ability to arrive at generalizations or concepts."

Heath's (1964) study demonstrated that students in PSSC physics, an inquiry-oriented course, preferred challenging/questioning responses on his CPT. It may be speculated that these students were acquiring the method, attitudes, and understanding of inquiry which Gagné (1963) believes is essential for their education.

Barnett (1974), suggesting that inquiry teaching and learning are related to cognitive preferences, investigated the relationships of these preferences to achievement and teaching style. Barnett (1974) used Atwood's (1971) cognitive preference test which had three options (memory-M, application-A, and questioning-Q) rather than the four options suggested by Heath (1964).

Atwood (1971) did not include the fundamental principles option on his CPT since he considered it

to be less distinct than the other three options. Brown (1975) agrees that the memory (M) and fundamental principle (P) options may be measuring the recall of information, but at different levels of generalization. Furthermore, Barnett (1973) and Atwood (1971) have suggested that the application of information (A) is more characteristic of inquiry behavior than traditional behavior.

Since a three option CPT is used in this study, the rationale for its selection will be discussed in more detail in a later chapter. Barnett (1974) indicated that students with a preference for application-questioning would tend to be better inquirers than students who exhibited a preference for memory responses.

Williams (1975), in his study of the cognitive preferences of college students, suggests another avenue of research. He points out that,

> One of the groups of students for whom most differences were detected was a vocational-technical group. One of the reasons suggested for their greater use of application preferences than other groups was the influence of the practically orientated courses they were following. Those who adopt a personality theory of vocational choice would suggest that persons with practical orientations seek out vocations which are congruent with their personalities. If this is so then an important area for further investigation will be the relationship of personality attributes to cognitive preferences.
> (p. 76)

However, no studies have been reported which attempts to determine the relationship between personality attributes and cognitive preference orientation.

Personality Attributes

Of the numerous theories postulated in an attempt to define personality, the theory of psychological types formulated by C. G. Jung (1923) appears to be potentially useful in studying the relationship between personality attributes and cognitive preference orientation. "The gist of the theory is that much apparently random variation in human behavior is actually quite orderly, being due to certain basic differences in the way people prefer to use perception and judgment" (Myers, 1962a, p. 1). According to Jung (1923), there are two basic pairs of psychological functions which characterize the attitudes of perception and judgment. Although these functions are used by all individuals, they are not equally preferred.

Perception is the process of becoming aware of people, ideas and things. Perception may occur by one of two functions: sensing or intuition.

Sensing is the familiar mode of perceiving using the five senses. A preference for sensing leads to skills in observation and to an interest in that which is real, tangible and factual. Sensing types (S) can be

characterized as observant, realistic, practical and factually oriented (McCaulley, 1976b).

Intuition "... is understood as indirect perception by way of the unconscious, with the emphasis on ideas or association which the unconscious tacks on to the outside things perceived" (Myers, 1962a, p. 1). Many individuals are familiar with the female's "sixth sense," the gentlemanly "hunch" or the "inspiration," divine or otherwise, characteristic of intuitive perception. Intuitive types (N) often see the possibilities, are interested in discovering patterns and relationships from events, and oftentimes tend to become theory-minded (McCaulley, 1976a).

Judgment is the rational process of decision-making. Judgment may be achieved by one of two functions: thinking or feeling.

Decision-making by thinking tends to be objective, analytical and logical, impersonal between that which is true and that which is false. Feeling does not refer specifically to the emotions, but to decision-making characterized by "... ordering events into priorities and importance, weighing values" (McCaulley, 1976a, p. 1). Feeling types (F) often develop the ability to understand people, their problems, their values. Thinking types (T) tend to feel most comfortable when events can be ordered in terms of cause and effect.

In addition to perception-judgment, Jung (1923) postulated another attitude about an individual's orientation to life, namely, extraversion*-introversion. The Extraverted type (E) is oriented toward objects and people in the environment, whereas the Introverted type (I) is oriented toward the inner self. A brief analogy might aid in understanding these attitudes. In extraversion, objects and people in the environment act as magnets, drawing the person toward them. In introversion, the person acts as a magnet, drawing the environment toward him.

The extravert, being drawn toward the external world, confronting it and becoming actively involved with it, tends to become "... action-oriented, sociable, outspoken and often impulsive" (McCaulley, 1976b, p. 730). The introvert, being drawn into the inner world of the self, tends to focus attention on understanding phenomena in depth, and "... becoming a more contemplative, deliberative person, interested in clear conceptualization of events" (McCaulley, 1976b, p. 730).

Jung (1923) himself never constructed a test instrument which would put his theory into practical use.

---

*Although some references use extroversion as the correct spelling of this word, extraversion will be used in this study in keeping not only with Jung's translators but also with standard typological usage in the literature.

> As a matter of fact, there is reason to doubt that he would have approved of such an attempt. He expressed his hesitancy about the use of his theory for statistical studies in a letter to Erich von Fange when the latter began his work on a study involving the use of the Myers-Briggs Type Indicator in early 1960.
> (Kramer, 1977, p. 49)

Whether or not Jung (1923) would have approved, several investigators have developed instruments in order to implement his theory. The Myers-Briggs Type Indicator (MBTI) is one of the more successful instruments.

Developed by Isabel Briggs Myers and Katharine Briggs, the MBTI has been used with persons of junior high school age and older. Myers (1962a) suggests that the Indicator has a,

> ... particular utility for counseling situations involving persons with problems of academic motivation and effective achievement; of choice of curriculum, college or academic major; of identification of preferences differentially expressible in various work roles, and delineation of job characteristics within which search for compatible vocational outlets may be conducted; or verification of tentative vocational choice, or search for factors in vocational development and adjustment; and of difficulties of communication or of understanding and interaction with other persons with whom the individual is cast. (p. 78)

She continues,

> The Indicator would seem useful in adapting the educational program, with all its aspects--social, disciplinary, extracurricular, as well as academic--to meet

> the needs of the majority of students or type groups that find rough sledding therein. (Myers, 1962a, p. 81)

In addition to Jung's (1923) six basic preferences, Myers (1962a) adds an additional scale describing a preference when dealing with the environment, i.e., in one's extraverted life. Judging types (J) prefer to take in just enough information in order to make a decision, whereas Perceptive types (P) tend to be more open, receptive, curious about events and in no hurry to make decisions. The judging types usually like to have a system and plan at hand, and prefer to control and regulate events in the environment. Perceptive types, since they are more open and curious individuals, tend to be alert and responsive to change. Understanding life and adapting to it is their wont. As McCaulley (1976a) points out, "Judging types are happiest when they can control events; perceptive types are happiest when they can understand events" (p. 2).

The eight basic preferences determined by the MBTI are "typed" into dichotomous categories along each of four dimensions, namely:

Direction of Interest

Extraversion (E) <----------> Introversion (I)

Perception

Sensing (S) <----------> Intuition (N)

Judgment

Thinking (T) ---------- Feeling (F)

Life Style

Judging (J) ---------- Perceiving (P)

The selection of one preference from each of the four dimensions generates a total of sixteen personality types as indicated in the "Type Table" (Figure 1), after Myers (1962a).

An examination of these personality types may offer some insight into the nature of an individual's cognitive preference orientation.

Need and Significance of the Study

Cognitive preference orientation can be one dimension of a student's overall cognitive style. Although Witkin, et al. (1967) and Heller (1977) maintain that cognitive style is a stable phenomenon, Heath (1964) has suggested that one dimension of cognitive style, viz., cognitive preference orientation, can be modified as a result of curriculum treatment.

As pointed out by Heath (1964), students in PSSC physics exhibited a question-principle orientation while those students in non-PSSC physics exhibited a memory-application orientation. However, some students in

ISTJ	ISFJ	INFJ	INTJ
ISTP	ISFP	INFP	INTP
ESTP	ESFP	ENFP	ENTP
ESTJ	ESFJ	ENFJ	ENTJ

Figure 1: Type Table: Myers-Briggs Type Indicator

the PSSC physics classes still exhibited a memory-application orientation. Some students in other inquiry programs, such as BSCS biology, CHEM Study chemistry and ESCP earth science, also exhibited a memory-application orientation.

Likewise, many teachers were not comfortable with inquiry-oriented curriculum programs due to the characteristic teaching styles associated with them.

Ben Zvi, et al. (1979) have indicated that inquiry programs such as CHEM Study chemistry are not suitable for all students. They have suggested that the CHEM Study chemistry program is more suitable for students with higher I.Q.'s who prefer challenging-questioning responses on a CPT; students of lower I.Q., who prefer the recall of statements (memory), should receive an alternative form of instruction.

Most eighth-graders take science. Traditionally, their placement in and/or choice of senior high school science programs usually depends on their academic achievement and I.Q. (oftentimes supported by teacher recommendations) with little concern for other relevant factors. Yourman (1964) has indicated that achievement and I.Q. alone are inadequate for such decision-making, especially with children of low I.Q. Cameron (1968), in his studies with culturally disadvantaged children, believes that an investigation of other relevant factors

is desirable as measures for later success.

Reynolds and Hope (1970) suggest that non-intellective sociological, personalogical and physical factors might be modifying variables in the success or prediction of the success of students. Kempa and Dubé (1973) support this point of view for students in science. With the decline in the administration and use of I.Q. tests in many schools, a search for factors other than achievement and teacher recommendations would seem to be needed.

Jung (1923) has postulated a personality theory of psychological types. Perhaps the differing modes of perception (sensing vs. intuition) and judgment (thinking vs. feeling), and direction of interest (extraversion vs. introversion) may affect an individual's cognitive preference orientation, hence, the preference for an inquiry-oriented or traditional classroom setting.

Heath (1964) has indicated that the cognitive preference orientation of most students can be changed due to curricular treatment. Perhaps these same personality types may affect the ease with which the cognitive preference orientation of students is changed, and the permanence of such a change.

An investigation of these concerns would be most beneficial for teachers and curriculum planners, especially with the current thrust for multidisciplinary,

inquiry-oriented, individualized approaches to science education. Knowledge of personality types and their relationships to cognitive preference orientation, might aid teachers and curriculum planners in selecting materials and instructional strategies in order to meet the needs of individual students and to promote success in any type of science class. Placement in science programs would not be limited to such factors as achievement scores, teacher recommendations, and I.Q. levels in schools which still use such scores.

Williams (1975) feels that the interacting effects of personality attributes and cognitive preference orientation have recieved inadequate attention in the literature. He asks,

> What sort of outcome could be expected if a teacher who showed minimal preference for principles and applications was set to teach a class of predominantly factually oriented students with the aim of developing skills in identifying fundamental principles? Would the teacher's chance of success be enhanced or minimized if he characteristically displayed authoritarian personality attributes? (p. 76)

Rudisill (1972) found that certain MBTI personality types preferred certain teaching strategies in mathematics, e.g., some preferred an indirect approach while others preferred a direct approach to teaching. It may be speculated that students who are inquiry-oriented

(those who prefer the questioning, challenging and generalization of information) would feel more comfortable with or prefer the teacher who used the indirect approach; traditional students (those who prefer the memorization of information) would feel more comfortable with or prefer the teacher who used the direct approach.

Knowledge of the relationships between cognitive preference orientation and MBTI personality types could be used in several ways. An additional criterion would be available, in addition to achievement scores, I.Q. scores and teacher recommendations, for placing students in a particular science program. In addition, students could be matched with a compatible teacher: who is traditional (direct) in approach or who prefers an inquiry (indirect) approach.

Furthermore, Voss (1979) has indicated that the attitudes of many students toward science and scientists are established by the time they leave junior high school. Perhaps their personality type may be a modifying variable affecting these attitudes. If this is so, such knowledge could be used in an attempt to reach those students who do not like science, either on a case-by-case approach, or by the development and/or modification of science programs.

With declining school enrollments, particularly in science classes (Helgeson, et al., 1977), and a lack

of interest in science, knowledge of those factors which not only can be used to keep students interested in science but also to select more science classes, would be a worthy investigative endeavor. This study is designed to help today's students who "... find rough sledding ..." in science classes.

Statement of the Problem

The purpose of this study was to determine the relationships among the MBTI personality characteristics, cognitive preference orientation, science achievement, intelligence, attitudes toward science and scientists, sex, and geographic area, of eighth-grade science students.

Information derived from this study can be used to help teachers and counselors assign students to science classes that are either more inquiry-oriented (open, indirect teacher behavior) or more traditional (fact-centered, direct teacher behaviors).

Direction of the Study

Cognitive Preference Orientation

Jerome S. Bruner (1960) has described two fundamentally different learning styles which he called "analytic thinking" and "intuitive thinking."

> Analytic thinking characteristically proceeds a step at a time. Steps are explicit and usually can be adequately reported by the thinker to another individual. Such thinking proceeds with relatively full awareness of the information and operations involved. It may involve careful and deductive reasoning, often using mathematics or logic, and an explicit plan of attack. Or it may involve a step-by-step process of induction and experiment, utilizing principles of research design and statistical analysis.
>
> In contrast to analytic thinking, intuitive thinking characteristically does not advance in careful, well-planned steps. Indeed, it tends to involve maneuvers based seemingly on an implicit perception of the total problem. The thinker arrives at an answer, which may be right or wrong, with little awareness of the process by which he reached it.
>
> (Bruner, 1960, pp. 57-58)

Bruner (1960) has further indicated that intuitive thinking is more characteristic of inquiry teaching and learning than analytic thinking. Since Myers (1962a) defines sensing and intuition in the same way as Bruner (1960) defines analytic and intuitive, it is expected that MBTI sensing types (S), those who need facts and prerequisite information, would exhibit a memory cognitive preference orientation, i.e., M, MA or MQ. It is also expected that MBTI intuitive types (N) would exhibit an application-questioning cognitive preference orientation, i.e., A, Q or AQ.

One of the goals of science education is to train students to be open-minded, to be aware of concepts and

ideas, to be imaginative, to be able to see relationships, and to be able to speculate beyond that immediately perceived, i.e., to be able to inquire. Such inquiry-oriented students are probably not only intuitive (imaginative), but also introverted (intellectual), thinking (impersonal and objective) and perceptive (aware). It is expected that MBTI introverted (I), thinking (T) and perceiving (P) types (in addition to the MBTI intuitive types (N)) would exhibit an application-questioning cognitive preference orientation. It is also expected that the MBTI extraverted (E), feeling (F) and judging (J) types (in addition to the MBTI sensing types (S)) would exhibit a memory cognitive preference orientation. Therefore, the general question may be asked,

> Question 1: Do eighth-grade science students, classified according to their MBTI personality types, differ in their cognitive preference orientation?

Intelligence

Three MBTI studies have been done using junior high school students as subjects. Myers (1962a), testing junior high school students in a pre-college-preparatory program, reported that students' highest I.Q. preferred intuition to sensing. Barberousse (1965), using a

similar population, came to the same conclusion that intuitive types ranked higher in mean intelligence quotient than sensing types. May (1971), using 375 eighth-grade students with ability in mathematics ranging from remedial to gifted, found that intuitive type students performed better than sensing type students on tests measuring mathematical computation, concepts and application; in addition, intuitive students performed better than sensing students on intelligence measures. In this study, the question may be asked,

> Question 2: Is there a difference in intelligence between eighth-grade science students classified according to their MBTI personality types and cognitive preference orientation?

Attitudes

One of the goals of the curriculum projects developed during the 60's and 70's was the development of positive attitudes toward science and scientists. Ramsey and Howe (1969) have stated that "A student's attitudes toward science may well be more important than his understanding of science since his attitudes determine how he will use his knowledge" (p. 68). These attitudes would include: open-mindedness; intellectual honesty; habits of accuracy; the ability to suspend

judgment; and the ability to seek cause and effect relationships. They would also include such characteristics as feelings, opinions, emotions and appreciations of the students. These same attitudes appear to be characteristic of inquiry learning.

Since many of the characteristics of these positive attitudes are similar to the characteristics of MBTI personality types, the question may be asked,

> Question 3: Do eighth-grade science students, classified according to their MBTI personality types, differ in their attitudes toward science and scientists?

In addition,

> Question 4: Is there any relationship between the attitudes toward science and scientists of eighth-grade science students and their intelligence?

Science Achievement, Sex and Geographic Area

The following questions were also proposed during the course of the study:

> Question 5: Do eighth-grade science students, classified according to their MBTI personality types and cognitive preference orientation, differ in science achievement?

Question 6: Is there any relationship between the science achievement of eighth-grade science students and their attitudes toward science and scientists?

Question 7: Is there any relationship between the sex of eighth-grade science students and their MBTI personality types; cognitive preference orientation; or attitudes toward science and scientists?

Question 8: Is there any relationship between the geographic area (urban, suburban, and rural) of eighth-grade science students, and their MBTI personality types; cognitive preference orientation; and attitudes toward science and scientists?

The relationships examined in this study are summarized in Table 1.

Hypotheses

In order to answer the above questions, the following null hypotheses were tested at the .001 level of significance:

TABLE 1

RELATIONSHIPS EXAMINED IN THIS STUDY

MBTI Personality Types	Cognitive Preference Orientation	Attitudes Toward Science & Scientists
AND	AND	AND
Cognitive Preference Orientation	Intelligence	Intelligence
Attitudes Toward Science & Scientists	Science Achievement	Science Achievement
Intelligence	Sex of Students	Sex of Students
Science Achievement	Geographic Area	Geographic Area
Sex of Students		
Geographic Area		

Question 1

Hypothesis 1: There is no statistically significant relationship between MBTI personality types and cognitive preference orientation.

Question 2

Hypothesis 2: There is no statistically significant difference between mean intelligence scores of the MBTI personality types.

Hypothesis 3: There is no statistically significant difference between mean intelligence scores of students classified according to their cognitive preference orientation.

Question 3

Hypothesis 4: There is no statistically significant difference in attitudes toward science and scientists between the MBTI personality types.

Question 4

Hypothesis 5: There is no statistically significant relationship between intelligence and attitudes toward science and scientists.

Question 5

Hypothesis 6: There is no statistically significant difference in mean science achievement scores between the MBTI personality types.

Hypothesis 7: There is no statistically significant difference in mean science achievement scores between students classified according to their cognitive preference orientation.

Question 6

Hypothesis 8: There is no statistically significant relationship between achievement scores in science and attitudes toward science and scientists.

Question 7

Hypothesis 9: There is no statistically significant relationship between the MBTI personality types and sex of students.

Hypothesis 10: There is no statistically significant relationship between the cognitive preference orientation and sex of students.

Hypothesis 11: There is no statistically significant difference in attitudes toward science and scientists between males and females.

Question 8

Hypothesis 12: There is no statistically significant relationship between MBTI personality types and geographic area.

Hypothesis 13: There is no statistically significant relationship between cognitive preference orientation and geographic area.

Hypothesis 14: There is no statistically significant difference in attitudes toward science and scientists between students from urban, suburban and rural geographic areas.

Assumptions

1. There has been no deliberate misrepresentation in the responses provided by the students on any of the test instruments.

2. The results of the study will not be affected by the personality type and/or teaching style of the teachers of the students.

3. The results of the study will not be affected by the type of science class the student was taking.

4. The cognitive preference dimension of cognitive style can be measured by a paper-pencil, achievement test, i.e., a cognitive preference test.

5. Students in the study have been exposed to, either in their science/social science classes or as part of their general education, the content presented in the CPE-II.

6. The MBTI personality types of individuals can be measured by the time they are in the eighth-grade.

7. The cognitive preference dimension of an individual's cognitive style may not be stable over time, and may be subject to modification and/or change as a result of curricular treatment.

8. Since I.Q. tests were not administered in the schools used in this study, it is assumed that an adequate measure of intelligence can be obtained by mathematically converting the raw vocabulary score from the standardized reading tests taken by the students.

Limitations of the Study

1. The participants are limited to those students taking eighth-grade science in urban, suburban and rural junior high/middle schools who volunteered for the study. They may or may not be representative of eighth-graders in similar school environments in the general population.

2. The study is limited by the time during the school year in which the tests were administered, viz. May 1979.

3. The study is limited by the relationships herein selected for investigation.

Definition of Terms

Cognitive Preference Orientation

The characteristic way in which an individual attends to the subject matter of a particular course of study.

Cognitive Preference Options

Recall or Memory (M): The acceptance of information for its own sake, with no consideration for its possible implications, application or limitations.

Application (A): The acceptance of information in view of its practicability and applicability in a general, social or scientific context.

Questioning (Q): The critical questioning or challenging of information as to its completeness, validity or limitations.

Principles (P): Acceptance of information because it characterizes or explains some fundamental principle or relationship. (This option is not used in this study.)

Personality Types

Personality types, as used in this study, are defined as those types determined by self-report using the Myers-Briggs Type Indicator, based on C. G. Jung's (1923) theory of psychological types.

Perception

The process of becoming aware of phenomena, people, objects, ideas or occurrences. Two basic modes of perception, used by all, but not equally preferred, are:

Sensing (S): Perceiving by means of the five senses.

Intuition (N): Indirectly perceiving by means of the unconscious.

Judgment

The process of making decisions about what has been perceived. Two basic modes for making judgments, used by all, but not equally preferred, are:

Thinking (T): Making analytical, objective, impersonal judgments in terms of cause and effect.

Feeling (F): Making value judgments; ordering events into priorities before judging.

Jungian Attitudes

Different ways of meeting the world, i.e., direction of interest:

Extraversion (E): Being drawn toward the external world, confronting it and becoming actively involved with it.

Introversion (I): Defending one's self against the impact of the world, desiring to conceptualize it clearly and understand phenomena in depth.

Myers' Attitudes

A scale developed by Myers (1962a) describing a preference for using a perceptive or judging attitude in an individual's extraverted life, i.e., a preferred life style:

Judging Attitude (J): Tending to seek system, order, organization and planning in dealing with the external environment.

Perceptive Attitude (P): Tending to be receptive, open and curious about phenomena in dealing with the external environment.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

Science educators usually rely on the results of one or more tests given to students to make their predictions and generalizations. Tests measuring such variables as aptitude, intelligence, achievement and other intellectual attributes are the most frequently employed to predict success in science. The scientifically accurate identification of those variables which would guarantee the success of science students at all educational levels would be an ambitious and unprecedented achievement for science educators.

Although knowledge of students' aptitude, intelligence and achievement is necessary, a growing body of educators believe than an examination of non-intellective physical, sociological and personalogical variables is also necessary to better characterize science students and to predict their success (Cameron, 1964; Atwood, 1969; Reynolds and Hope, 1970; Kempa and Dubé, 1973; Rowe, 1978). Cognitive preference style and personality attributes would both be included as important variables affecting the success of science students.

Cognitive Preferences

Robert W. Heath (1964) constructed the first cognitive preference test (CPT) to determine whether or not the goals of PSSC physics, an inquiry-oriented course, were being achieved. In selecting memory (M) and application (A) as characteristics of traditional physics classes, and questioning (Q) and fundamental principles (P) as characteristics of PSSC physics, Heath (1964) found that PSSC physics students demonstrated a stronger preference for Q-P than students in traditional physics classes, the latter demonstrating a stronger preference for M-A than PSSC physics students. (Although Heath (1964) reported a difference in the A option in the direction indicated, it was not statistically significant.) Furthermore, a preference for Q-P was demonstrated to be more positively related to achievement for PSSC physics students than for students in traditional physics classes. Likewise, a preference for M-A was found to be more negatively related to achievement for PSSC physics students than for students in traditional physics classes.

Following Heath's (1964) example, Marks (1967) designed a four-option CPT to determine whether or not the goals of Chemical Bond Approach (CBA) chemistry (also an inquiry-oriented course) were being achieved.

Like Heath (1964), the options on Marks' (1964) CPT were designed to reflect a preference for the memory of specific facts and terms (M), practical applications (A), critical questioning of information (Q), or the identification of a fundamental principle (P). The following example illustrates these options:

> Vegetable oils become fats by combining oil with hydrogen. [Stem]
>
> a) Crisco is the result of such a process. [Application]
>
> b) The process is called hydrogenation. [Memory]
>
> c) Hydrogen can be added to certain unsaturated bonds. [Principle]
>
> d) Addition of hydrogen to vegetable oils liberates heat. Saturated fats are therefore more stable than unsaturated fats. [Questioning]
>
> (Marks, 1966, p. B-2)

Marks (1967) reported that CBA students exhibited a strong preference for Q-P. Students in a traditional chemistry course exhibited a strong preference for M. Both had virtually the same preference for A. Essentially, these were the same results that Heath (1964) reported in his study.

Mackay (1972) conducted a study using PSSC physics students in Victoria, Australia, high schools. These students took physics for two years as opposed to the traditional American one-year course. By testing the students at the beginning and end of the eleventh-grade

and at the end of the twelfth-grade, Mackay (1972) discovered a shift in the cognitive preference orientation of these students from memory (M) to identification of principles (P), and from practical application (A) to critical questioning and theoretical extension of information (Q).

Tamir (1975) constructed the first CPT for use with biology classes. A typical item follows:

> Penicillin was discovered by Alexander Flemming in 1928. [Stem]
>
> a) Penicillin is extensively used by doctors in the treatment of bacterial infections. [Application]
>
> b) Penicillin is an antibiotic drug. [Memory]
>
> c) Penicillin, like other antibiotics, is produced by a living micro-organism and is effective in the control of other micro-organisms. [Principle]
>
> d) Penicillin is not an effective treatment of all bacterial diseases and a whole range of other compounds have been developed to treat bacterial diseases. [Questioning]
>
> (Tamir, 1975, p. 240)

Tamir (1975) found that the BSCS biology students had a higher preference for Q and a lower preference for M when compared to non-BSCS biology students, partially reflecting the nature of the inquiry-oriented BSCS program. No difference was reported between the two groups for P or A.

Therefore, the studies of Heath (1964),

Marks (1967), Mackay (1972), and Tamir (1975) tend to support the proposition that the cognitive preference orientation of students may be affected by curricular treatment.

Atwood (1967-68a) departed somewhat from Heath's (1964) original conceptualization of cognitive preference testing by not comparing CHEM Study chemistry to a traditional chemistry class. Furthermore, he suggested that the practical application (A) option was more characteristic of an inquiry-oriented program than a traditional class. He also suggested that certain combinations of preferences might be more advantageous than others relative to the achievement of CHEM Study students. Atwood,

> ... concluded that students who showed a strong preference for the memory of specific facts [or the combinations M-A, M-Q, M-P] were at a disadvantage in the CHEM Study course relative to those who showed a strong preference for fundamental principles, critical questioning of information, and practical applications [and that] a strong preference for practical applications in combination with a preference for fundamental principles or critical questioning [A-P, A-Q] may be most advantageous in this respect. (1967-68b, p. 159)

While Atwood's (1967-68b) study was designed to determine if one of the desired goals of the CHEM Study program was being achieved by the cognitive preference orientation of CHEM Study students, Marks (1967) and

Mackay (1972) went further. They speculated that cognitive preferences might be indicative of a student's cognitive style. Schmedemann and LaShier (1967-68), Kempa and Dubé (1973), Williams (1975), Tamir (1975), and Tamir and Kempa (1978) share this point of view.

Witkin, et al. (1967) have expressed the view that cognitive style is relatively stable over time and is independent of content, i.e., independent of the type of information presented to the student. Glaser (1970) opposes this point of view, suggesting that teachers, by directing students' thought processes, are able to influence their cognitive style. The studies of Heath, et al. (1964) tend to lend credence to Glasser's (1970) point of view.

There is agreement that individuals characteristically exhibit cognitive <u>styles</u> rather than a single generalized style. Kempa and Dubé (1973) believe that "discipline-oriented" cognitive styles may be influenced by teaching style and curricular treatment. However, certain "discipline-free" cognitive styles may exhibit the stability over time as indicated by Witkin, et al. (1967). Williams (1975), in fact, recognizes cognitive preferences as one form of cognitive style exhibited by an individual.

Williams (1975) indicated that certain cognitive preferences may be stable. However, he was not referring

to stability over time but to stability of preference from one discipline to another. Atwood (1969), suggesting that a transfer of cognitive preferences, hence, a transfer of cognitive style, might occur between closely related disciplines, found no evidence to support his proposition.

Tamir (1975) found that the cognitive preference styles of students in chemistry were quite different from the cognitive preference styles of those same students in biology. In chemistry, all students tended to prefer M and P; in biology the reverse was true for A and Q. This point would indicate that the students in Atwood's (1969) study differed in their cognitive preference orientation due to the nature of the subject matter and not to inquiry-orientation per se.

In addition to reporting discipline-dependent cognitive preference styles, Tamir (1975) found that different styles may be exhibited within disciplines. Students in a human biology class seemed to prefer practical application (A) items. Students in botany and biochemical processes classes tended to select practial application (A) items least.

Williams (1975) found evidence to suggest that a preference for practical applications (A) might transcend the disciplines. Tamir and Kempa (1978) reported that students in their study exhibited a general pattern of

P to M to A to Q which cut across the three major science disciplines: namely, biology, chemistry and physics.

The studies summarized above would indicate, as suggested by Tamir (1975), that cognitive preference styles may consist of three distinct dimensions.

One dimension represents some general characteristic of an individual student, consisting of an inate component (nature) and another component acquired by experience (nurture). This dimension may reflect a cognitive preference style which transcends the disciplines, i.e., a "discipline-free" cognitive style.

A second dimension represents a "discipline-dependent" cognitive preference style, i.e., one reflecting the subject matter nature of biology, chemistry, etc. Most CPT's developed thus far measure this dimension.

A third dimension represents the subject matter of a sub-discipline, e.g., botany or zoology (biology), physical chemistry or biochemistry (chemistry), and mechanics or nuclear physics (physics).

Payette (1967) developed a CPT using subject matter derived from the social sciences. Unlike Heath (1964) and others, Payette (1967) considered cognitive preferences to reflect affective rather than cognitive behavior. Such affective behavior would be expressed in

a consistent manner corresponding to level 2.2 ("Willingness to Respond") of the Taxonomy of Educational Objectives, Handbook II: Affective Domain (Krathwohl, et al., 1964).

Brown (1975) also suggested that cognitive preferences may be indicative of affective behavior. She pointed out that students may prefer a certain choice on a CPT because of the content in a statement rather than the underlying process of memorizing, applying, questioning, or recognizing a fundamental principle. Since the students seem to value the content of one statement over others, such behavior would correspond to level 3.2 ("Preference of a Value") as indicated by Krathwohl, et al. (1964).

Furthermore, students may choose a statement because they recognized some phraseology or other identifying characteristic of their teacher. Such students would conform to an authority figure, i.e., to please the teacher, corresponding to level 2.2 ("Willingness to Respond") or level 2.3 ("Satisfaction in Response"), as indicated by Krathwohl, et al. (1964).

Likewise, in a four item test, students know that they must select one of the items. This behavior, characteristic of Krathwohl, et al.'s (1964) level 2.1 ("Acquiescence in Responding"), would tend to result in random choices with no emotional significance attached to them.

Brown, 1975) also suggests "... that the cognitive preferences M, P, A, and Q represent ... preferences for statements implying cognitive behavior at the level of Knowledge (level 1.0), Comprehension (level 2.0), application (level 3.0) and Synthesis (level 5.0)" (p. 56). These levels have been explained by Bloom, et al. (1956). Students at the level of Knowledge would be expected to prefer consistently M responses on a CPT. In a heterogeneous class with students of differing cognitive abilities, an "Acquiesence in Responding" mode would probably prevail. Students at the level of Knowledge would select M; students at the level of Comprehension would select M and P; students at the level of Application would select M, P, and A; and students at the level of Synthesis would select M, P, A, and Q. Brown (1975) cites an unpublished study she conducted with junior high school students (ages 13-14) which would seem to support her hypothesis.

The general concensus is that cognitive preferences represent some dimension of an individual's overall cognitive style and that this dimension can be measured on a paper-pencil CPT, reflecting preferences for M, A, Q, or P. However, the studies of Payette (1967) and Brown (1975) indicate that the exact nature of cognitive preferences needs further examination.

Ruth Ben Zvi, et al. (1979), in an attempt to

examine the nature of cognitive preferences as suggested by Brown (1975), conducted a study to find out if any relationships existed between cognitive preferences and learning modes in high school chemistry students. They have concluded that the pattern of responses on the CPT used in their study is independent of specific learning modes in chemistry. In addition, students with high I.Q.'s showed a preference for critical questioning (Q) responses, whereas students with low I.Q.'s showed a preference for the recall of facts (M).

Like Brown (1975), Ben Zvi, et al. (1979) have indicated that further research should be conducted to understand the nature of cognitive preferences.

Heath (1964) observed that some students in PSSC physics preferred the non-inquiry mode of responding (M and A) and suggested that perhaps the teacher of these students was teaching in the traditional manner (fact-centered). Tamir (1975) found that the most inquiry-oriented students (Q and P preferences) were not only in a BSCS biology class, but also were being taught by "BSCS supporting teachers." They have suggested that further studies be conducted as to how teaching styles affect the cognitive preference orientation of students.

Further suggestions for study include: an examination of the relationships between cognitive preference orientation and the achievement, interests

and attitudes of students (Tamir, 1975); how cognitive preferences develop with age (Kempa and Dubé, 1973); and the effects of personality on cognitive preference orientation (Williams, 1975). The present study will address, in part, the relationships between cognitive preference orientation, achievement, attitudes, and personality attributes.

Personality Attributes

A number of studies have shown that the personality attitudes of extraversion and introversion described by C. G. Jung (1923) affect academic achievement at different educational levels. Ridding (1967) found that high achieving twelve-year-old students tended to be more extraverted than low achievers, who tended to be more introverted. Eysenck and Cookson (1969) obtained similar results with eleven-year-old students. In general, extraversion correlates positively with achievement during the elementary years followed by a shift such that introversion correlates positively with achievement during high school and college (Cattell, et al., 1966; Savage, 1966).

This shift begins to occur while students are in the junior high/middle school when rapid and oftentimes unpredictable changes occur in students, as junior high school teachers (and parents of these students) so well

know. Cattell (1966) has promulgated that the shift in the influence of extraversion to introversion on achievement occurs between the age of twelve and the time a student completes high school. Entwistle and Welsh (1969) suggest that the shift begins to occur somewhat later, around age fifteen.

Although these studies were significant in that they demonstrated that the Jungian personality attitudes of extraversion and introversion affected achievement, they dealt with only part of Jung's (1923) theory of psychological types. Studies such as those of Myers (1962a), Barberousse (1965), and May (1971) utilized the Myers-Briggs Type Indicator (MBTI), which measured not only extraversion-introversion, but also the functions of perception (sensing and intuition) and judgment (thinking and feeling) described by Jung (1923), and the attitudes (judgment and perception) described by Myers (1962a). These and other studies indicated that significant relationships exist between MBTI personality types and selected educational variables.

Myers (1962a) reported that seventh- and eighth-grade students of the highest I.Q. in a pre-college preparatory course preferred the intuitive rather than the sensing mode of perception.

Barberousse (1965) conducted a study in which she investigated the variability of 280 eighth-grade students'

behavioral responses on creativity criteria, intelligence and sociometric choices in relation to MBTI personality types. Like Myers (1962a), she found that students highest in I.Q. were more intuitive than sensing; like Cattell, et al. (1966), students highest in I.Q. were more extraverted than introverted. She also found that high I.Q. students were more thinking than feeling and more perceiving than judging. In addition, Barberousse (1965) reported that teachers preferred extraverted, sensing students over introverted, intuitive students.

May (1971), also testing eighth-grade students, reported that intuitive students performed better than sensing students on mathematic's achievement and comprehension tests, and on intelligence tests. However, May (1971) could not definitely conclude if the intuitives performed better because of their personality type, their intelligence or a combination of the two factors.

In her 1968 study, Hedley,

> ... indicated that the person of high intelligence and science ability tended to have somewhat anxious behavior combined with literary and musical interests, but was lacking in the qualities of accuracy with factual material and compulsiveness, indicating that the person with science attitude and high intelligence may tend to "hang loose" defensively. (p. 271)

Hedley (1968) suggested that further studies be done with

different and more distinctive measures so that the implications might be of benefit to counselors and vocational guidance personnel.

Reynolds and Hope (1970), using the MBTI, characterized the ideal science students in terms of Jungian typology.

> In terms of an ideal science student typology, it was thought that the successful individual would be introverted, intuitive, thinking and perceptive, i.e., he would be more intellectual, more imaginative, more impersonal or objective, and more aware than the student in the general population.
> (Reynolds and Hope, 1970, p. 712)

The subjects in their study consisted of 158 ninth-grade general science students, 168 tenth-grade biology students and 58 students taking chemistry as an elective. Overall science achievement scores tended to be higher for introverts than for extraverts, and also higher for intuitives than for sensers in all three groups. No significant differences were found between thinkers and feelers in the three groups. Perceptives' achievement scores were higher than judgers' scores in the ninth-grade, while no significant differences were found in the tenth-grade biology and chemistry students.

Reynolds and Hope (1970) found more INTP students in the elective chemistry course (in the direction that they postulated) and that "... in science achievement

some benefit accrues from being both introverted and intuitive" (p. 716), not only in terms of science achievement but also in terms of I.Q. and grade point average.

Based on the effects of the combinations of perception and judgment, Myers (1962b) has characterized individuals as follows:

> Sensing plus Thinking. ST people are mainly interested in facts, since facts are what can be collected and verified directly by the senses--by seeing, hearing, touching, etc. And they make decisions on these facts by impersonal analysis, because the kind of judgment they trust is thinking, with its step-by-step process of reasoning from cause to effect, from premise to conclusion.
>
> Sensing plus Feeling. SF people are also interested in facts, but make their decisions with personal warmth, because the kind of judgment they trust is feeling, with its power to weigh how much things matter to themselves and others.
>
> Intuition plus Feeling. NF people make decisions with the same personal warmth. But, since they prefer intuition, their interest is not in facts but in possibilities, such as new projects, things that have not yet happened but might be made to happen, new truths that are not yet known but might be found out, or, above all, new possibilities for people.
>
> Intuition plus Thinking. NT people share the interest in possibilities. But, since they prefer thinking, they approach these possibilities with impersonal analysis. Often the possibility they choose is a theoretical or technical one, with the human element more or less ignored.
>
> (Myers, 1962b, p. 3)

Mary H. McCaulley (1976a), the Director of the Center for the Application of Psychological Type (CAPT),

Gainesville, Florida, has described in some detail the types expected to be found among scientists and students interested in science, based on the combinations described by Myers (1962a).

1. Sensing plus Thinking: The "practical and matter-of-fact" ST types would be expected to be attracted to sciences where critical observations and classification are required, viz., the biological sciences.

2. Sensing plus Feeling: The "sympathetic and friendly" SF types probably would not be found in significant numbers among scientists and students interested in science, unless information could be of practical benefit to mankind.

3. Intuition plus Feeling: The "enthusiastic and insightful" NF types most probably would be attracted to the behavioral sciences.

4. Intuition plus Thinking: Most scientists, especially those in the physical sciences, were expected to be of the "logical and ingeneous" NT types.

McCaulley (1976a) has also indicated that more IN types, whose major interest is in "knowledge for its own sake," would be found among scientists and those interested in science than ES types, whose preference is for that

which is practical and real. McCaulley (1976a) continues:

> Since intuitives are postulated to have a greater interest in finding patterns in complex events, we expected more EN types than ES types among scientists. Since introverts are more interested in clarification of concepts and ideas, we expected more IS types than ES types among scientists. (p. 3)

Thus, McCaulley (1976a) has predicted that for scientists and for students interested in science:

1. Introverts will outnumber extraverts.

2. Intuitive types will outnumber sensing types.

3. More thinking types will be attracted to the physical sciences.

4. More feeling types will be attracted to the behavioral sciences.

The columns of the type table (see Figure 1, p. 15) would follow a pattern: NT > NF > ST > SF. The quadrants of the type table would follow a pattern: IN > EN > IS > ES.

Both Myers (1962a), reporting Holland's 1960 data for 1001 National Merit Finalists, and McCaulley (1976a), reporting data for 314 high school Florida Future Scientists, found that introverts outnumbered extraverts and intuitives outnumbered sensers such that NT > NF > ST > SF and IN > EN > IS > ES, as predicted.

In both studies, more feeling types were found among females and more thinking types among males. However, the overall distribution of types suggested that certain "science-minded" types were more attracted to the sciences, regardless of sex.

Although more thinking types were attracted to science than feeling types, nonsignificant differences are usually reported between them on various science measures. This conclusion would suggest that intuition is probably more important than thinking in both science aptitude and science achievement (Reynolds and Hope, 1970; McCaulley, 1976a).

The personality types previously described have been recognized by classroom teachers, but not necessarily in terms of Jungian psychology. Fischer and Fischer (1979) have characterized various learning styles which seem remarkedly similar to the psychological types described by Myers (1962a). A comparison of selected MBTI personality types and learning styles described by Fischer and Fischer (1979) is presented in Table 2.

Fischer and Fischer (1979) offer a caveat concerning the described learning styles: One style is not "better" than another style, and equally intelligent individuals may prefer one style over another. Myers (1962) and McCaulley (1976b) also offer a similar caveat: Although the basic components (i.e., the

TABLE 2

COMPARISON OF SELECTED MBTI PERSONALITY TYPES TO LEARNING STYLES DESCRIBED BY FISCHER AND FISCHER (1979)

MBTI Personality Types Myers (1962a)	Learning Styles Fischer and Fischer (1979)
Sensing (S)	Sensory Specialists and Sensory Generalists
Work with known facts via the senses.	Use the senses to gather information and gain insights.
Intuitive (N)	Intuitive Learner
Look for possibilities and relationships.	Leap in various directions, generalizes, unsystematically gathers information.
Thinking (T)	Emotionally Neutral
Make judgments based on impersonal analysis and logic.	Classroom tone characterized by intellectual understanding and analysis.
Feeling (F)	Emotionally Involved
Judgments made via personal values.	Active discussions where strong positions are stated, defended, adopted, or discarded after dynamic interplay of ideas and activities.
Judging (J)	Explicitly Structured
Planned, orderly way of life; control events.	Clear, unambigious learning; goals explicitly stated; specific behaviors defined.
Perceiving (P)	Open-ended Structure
Flexible, spontaneous way of life.	Overall structure, but place for divergence, exploration of relevant but not preplanned phenomena.

attitudes and functions) are the same in all individuals, differences exist in the characteristics that result from their interaction. Each personality type provides its own excellence; no one personality type is "better" than another.

However, as previously indicated, some types may have some advantage in terms of success in science, i.e., some individuals may tend to be more "science-minded." However, as McCaulley (1976a) has pointed out, "... all types can and do learn science" (p. 5). After analyzing studies in this area, it is the assumption of this writer that the responsibility of science teachers, curriculum planners, counselors, parents and others interested in the education of students at all educational levels, is to provide for all the different types in a given class, not only for those who are "science-minded" but the majority of "less science-minded" students as well.

Attitudes

Although many studies have addressed attitudes, this term is rarely defined within a given study. Often an attitude study is actually a study of student "interests." Perhaps some confusion results from definitions such as Bem's (1970), who considers attitudes to be "likes and dislikes," i.e., affinities and

aversions toward persons, groups, situations, ideas, etc. Khan and Weiss (1973) also use the like-dislike connotation of attitudes as the focus of their review on the teaching of affective responses in the Second Handbook of Research on Teaching.

Studies of the interests of junior high school students, i.e., their likes and dislikes for science topics, have been of value for teachers and curriculum planners (Glenn, 1958; Bagshaw, 1959; Palmer, 1977). Capitalizing on current interests is an excellent instructional strategy to motivate students (Voss, 1968). However, the interests of students may be transitory (Ringness, 1975). What is of interest (and the interest may be intense!) at one point in time may be replaced by another interest of equal intensity. The popular television series, musical group, hobby or fad captures the interest of an audience for a brief time.

Attitudes involve more than a mere like or dislike, intensity notwithstanding. They are more stable than interests (Klausmeier and Ripple, 1971). Klausmeier and Goodwin (1966) define an attitude as an "... emotionally toned predisposition to react in a consistant way, favorable or unfavorable, toward a person, object or idea" (p. 343). Miller and Blaydes (1962) define an attitude as "... a condition of mind involving imagination and emotional states which are the result of past

experiences. Attitudes condition behavior, establishing patterns of conduct. Attitudes are ethics" (p. 20).

Ramsey and Howe (1969) have indicated that the development of positive attitudes toward science and scientists should be emphasized in science curricula, since these attitudes may determine how science knowledge is used. Miller and Blaydes (1962) also believe that educating individuals for attitudes is of paramount importance. They have stated that,

> If there is any one thing that the study of science should do for the student it is to produce a scientific attitude toward all problems that arise in his daily life. Facts, if not used, may be forgotten, but the establishment of an attitude which impels an individual to look at each problematic situation in an analytic fashion, to attack it in a scientific manner, to demand proof in the form of adequate facts results in a habit of thinking which can and will be used regularly by the individual in making the innumerable adjustments that are necessitated by a constantly changing society. (p. 22)

Mead and Metreaux (1957) analyzed the responses of approximately 35,000 high school students regarding their perception of the scientist. The students responded to three items:

a) When I think about a scientist, I think of ...

b) If I were going to be [to marry--option for girls] a scientist, I should like to be [to marry] the kind of scientist who ...

c) If I were going to be [to marry] a scientist, I would not like to be [to marry] the kind of scientist who ...

Although students generally perceived scientists as intelligent and dedicated individuals, their composite image included remarks as:

> His work is uninteresting, dull, monotonous, tedious, time-consuming.
>
> He may live in a cold-water flat; his laboratory may be dingy.
>
> He is so involved in his work that he does not know what is going on in the world.
>
> He has no other interest and neglects his body for his mind.
>
> He can only talk, eat, breathe, and sleep science.
>
> He neglects his family--pays no attention to his wife, never plays with his children.
>
> He has no social life, no other intellectual interest, no hobbies or relaxations.
>
> He bores his wife, his children and their friends--for he has no friends of his own or knows only other scientists--with incessant talk that no one can understand.
>
> No one wants to be such a scientist or to marry him.

Thus, although these students regarded scientists in a positive manner, their attitude was negative with personal involvement.

McNarry and O'Farrel (1971) reported that 79 urban and 161 rural high school students regarded scientists

as "helpful, wise and important" but also "hard, old, frightening and colorless."

Ahlgren and Walberg (1973) indicated that the negative attitudes toward science and scientists were not changing with time or geography. They believe that, "The relation of ... science to people--through being beneficial, social, artistic and humanitarian--seems to offer the best chance to regain lost interest in a lost audience" (p. 189). The development of current junior high/middle school interdisciplinary/multidisciplinary science/social science programs such as the BSCS Human Sciences Program, would seem to be congruent with Ahlgren and Walberg's (1973) suggestion for developing positive attitudes toward science and scientists in students.

Factors other than curriculum affecting the development of positive attitudes toward science and scientists have been investigated. Motz (1970) analyzed the attitudes toward science and scientists of 981 males and females, sixth- and ninth-grade students from urban, suburban and rural areas. Motz (1970) reported that while no difference between males and females could be detected, students with higher socio-economic backgrounds had a more positive attitude toward science and scientists than students from lower socio-economic backgrounds. Likewise, ninth-grade students had a more positive attitude toward science and scientists than sixth-grade

students. Sixth-grade suburban and ninth-grade rural students had more positive attitudes toward science than sixth-grade rural and urban students. In addition, ninth-grade urban students had less positive attitudes toward science and scientists than did ninth-grade rural and suburban students, but more positive attitudes than either rural and urban sixth-grade students.

Wright (1962), in a study of 105 British secondary school students, indicated that parental influence was more important that teacher influence in the development of positive attitudes.

Yamamoto, Thomas and Karnes (1969) also suggested that students appeared to be more parent-oriented than teacher-oriented. Yamamoto, et al. (1969) investigated the school-related attitudes of 800 junior high school students (grades 6-9) from a suburban public school system in a north central state. In addition to their previous finding, they reported that "... boys gave a considerably more favorable rating to science than that given by girls" (p. 199).

However, a number of studies have indicated that the personality and behavior of the classroom teacher is also important in the development of positive attitudes toward science and scientists (Reed, 1968; Gardner, 1974). Anderson (1971) has indicated that teachers need to be enthusiastic and need to use indirect teaching behaviors

to ensure positive attitude development. McMillan and May (1979) also have indicated that the teacher's personality and interrelationships with students are crucial variables in positive attitude development.

Although studies analyzing the relationships between teachers' personalities and teaching style and the development of positive attitudes are found in the literature, few studies have been conducted to examine possible relationships between student personality types and positive attitude development.

Power (1977) has indicated that the favorable attitudes of eighth-grade science students are associated with high verbal interaction rates with teachers. However, Power (1977) has also indicated that these same teachers are hesitant to call on introverted, anxious students to respond in public situations. (These personality types were measured by the IPAT High School Personality Questionnaire.) It is not known whether the willingness of the introverted, anxious students to respond in public situations can be improved without increasing anxiety to a level where it interferes with performance, creates embarrassment and a negative attitude toward science.

May (1971), using the MBTI, found no significant differences between the attitudes toward mathematics of sensing and intuitive type students, as measured by the

Dutton Arithmetic Attitude Scale. However, he found in an informal study that judging types did have a more positive attitude toward mathematics than perceptive types.

The paucity of studies in the literature suggests that an examination of the relationships between students' personality types and attitudes toward science and scientists is essentially an unexplored subject. Yager (1978) suggestes that "... there is increasing need to study the means by which values and attitudes evolve..." (p. 100). The MBTI would seem to be a potentially useful instrument in examining the evolution and/or modification of student attitudes toward science and scientists.

The various research studies conducted indicated a continuing need to examine the cognitive preference orientation, personality attributes and attitudes of students. Although isolated studies have been conducted, there is a need to examine these variables with a particular group within the context of a given study. This study will explore the relationships among these and other variables with eighth-grade science students.

CHAPTER III

EXPERIMENTAL PROCEDURES

Selection and Description of the Sample

The subjects participating in this study consisted of 283 eighth-grade students (13- and 14-year-olds) taking science classes in urban, suburban and rural Michigan schools. The urban school is located in central Wayne County. The suburban school is located in southern Oakland County and the rural school is located in northern Oakland County. These schools were selected at random from a list of schools after consulting with the science supervisors of the Detroit Public Schools and Oakland County Schools.

Permission to conduct the study was then granted by the schools with the stipulation that participation in the study be strictly voluntary. The study was explained to each of the participants. A letter and consent form (see Appendix A) were sent to the parents of the participants. Both the letter and consent form had been approved by the schools and The University of Michigan Human Subjects Committee. The consent form was returned to the school with the required signatures before the study was conducted.

Students in the urban sample (N=82) were attending a middle school, grades 5-8. At this school, science is not required for a full year. However, the science students in the sample had previously taken a one-semester science class and were taking the current class as an elective. Traditional subject matter was covered, such as the human body, astronomy, rocks and minerals, etc.

Students in the suburban sample (N=71) were attending a junior high school, grades 7-9. Science is required for all students in the eighth-grade. However, students select one "minicourse" each quarter of the academic year. Although both seventh- and eighth-graders may elect the same minicourse, only eighth-grade students participated in the study. Although they represented the interests and expertise of the individual teachers, the topics of the minicourses followed traditional science content.

Although it is called a junior high school, students in the rural sample (N=130) were attending a middle school, grades 6-8. Students in the eighth-grade take Intermediate Science Curriculum Study (ISCS) science. The content of this inquiry-oriented curriculum program is supplemented with traditional junior high school science topics.

Thus, students in all three schools had taken

science for a full year and had been exposed to similar science topics.

Students in the urban and rural samples were considered to be members of the graduating class while those students attending the suburban school were in the middle of the junior high school program. Table 3 summarizes the samples used in this study.

Data Collection

Participants in the study agreed to take the following tests:

1. Science Knowledge Test (SKT)
2. Myers-Briggs Type Indicator (MBTI)
3. Cognitive Preference Examination II (CPE-II)
4. Science and Scientists Attitude Inventory (SASAI)

However, a number of students did not complete all four of the tests due to illness or other unforeseen problems. This is reflected by different N's associated with the data analysis.

Tests were administered to intact classes. Testing required approximately two and one-half class periods. The SKT and SASAI were administered during the first full class period, the MBTI during the second full class period and the CPE-II during the third half-period.

TABLE 3

SAMPLE FOR THE STUDY

Sample	School	Grades	N	Sex
Urban	Middle	5-8	82	M = 46 F = 36
Suburban	Junior High	7-9	71	M = 37 F = 34
Rural	Middle	6-8	130	M = 70 F = 60
		TOTAL	283	M = 153 F = 130

All tests were administered by this investigator on three successive days in each of the schools during May 1979. The coded answer sheets were then hand scored.

Description of Test Instruments

Science Knowledge Test

Achievement in science is measured in a number of ways, the most common methods being teacher-made tests, publisher's tests and standardized tests. However, the schools in this study did not give either publisher's or standardized tests in science. Achievement in science was measured only by teacher-made tests.

At first, using the final letter grade (A, B, C, D, and E) assigned to each student by the classroom teacher was considered. However, there were no consistent ways of assigning grades. Students in the rural sample received such a final letter grade; students in the suburban sample received four non-cumulative final grades, one for each minicourse they selected; and students in the urban sample received no letter grade. The urban students received a progress report indicating that they had or had not met certain teacher-prepared objectives in science.

Consequently, twenty items from the 1973 National Assessment of Educational Progress (NAEP) assessment of

science were selected to construct the Science Knowledge Test (SKT) used in this study.

Reliability. Reliability is the consistency with which a set of scores measures whatever they do measure. Several methods are commonly employed to measure reliability. The test-retest (repeated measures) method is accomplished by giving the same individual the same test twice. Thus, two scores for each individual would be obtained. The correlation between them would yield a test-retest reliability coefficient. The use of parallel forms of the same test would also produce scores which could be used to obtain reliability coefficients.

Because of time constraints, neither of the above methods were employed. Therefore, a third method was used which required only a single half-period testing session. The SKT was split into two equal halves for scoring purposes. For each student, separate scores were obtained for the 10 odd-numbered and 10 even-numbered items. A reliability coefficient of 0.62 was obtained for the SKT based on the correlation between the odd- and even-numbered scores.

However, the scores used to obtain the reliability coefficient of 0.62 represented only one-half of the length of the actual test. In order to obtain an estimate of the reliability of the full-length test, the Spearman-Brown Prophecy Formula was used. The Spearman-Brown

Prophecy Formula is used to predict the increase in reliability which results from lengthening of a test by adding items like those in the original test. The formula used is:

$$r_2 = \frac{2r_s}{r_s + 1},$$

where r_2 = the estimated reliability of the full-length test;

r_s = the actual correlation between the two half-length tests, in this case 0.62.

Thus, replacing 0.62 in the above formula,

$$r_2 = \frac{2 * 0.62}{0.62 + 1} = 0.77.$$

By using the Spearman-Brown Prophecy Formula, the estimated reliability of the SKT was determined to be 0.77.

Validity. According to the NAEP, subject matter specialists, school people and thoughtful citizens judged these items to be valid not only in terms of content but also for the junior high school age level (Womer, 1970; NSTA, 1973). Validity is a measure of the degree to which a test measures what it purports to measure.

Thirty items from the 1973 assessment were selected for possible use in this study and were shown to five junior high/middle school science teachers. All

agreed with the NAEP that the items were appropriate for use with junior high school students. However, because of time constraints (only one-half class period could be used for administering this test), the number of items was reduced from the original thirty to twenty (see Appendix B). The relationship of the final twenty items to the stated NAEP objectives is presented in Table 4.

Myers-Briggs Type Indicator

The Myers-Briggs Type Indicator (MBTI) is a 166-item, forced-choice, self-administering questionnaire constructed in the early 1940's by Isabel Myers Briggs and her mother, Katharine C. Briggs, to measure the psychological processes of perception and judgment described by C. G. Jung (1923). Form F, used in this study, consists of 114 forced-choices between two or three phrases or sentences and 52 forced-choices between a pair of words to determine which appeals more to the individual (see Appendix C).

As previously indicated, the four scales of the MBTI measure preferences for:

Extraversion vs. Introversion	(E or I)
Sensing vs. Intuition	(S or N)
Thinking vs. Feeling	(T or F)

TABLE 4

RELATIONSHIP OF NAEP OBJECTIVES TO ITEMS USED IN THE SKT

Objectives	Items
I. Know the fundamental aspects of science	
A. Know facts and simple concepts	
Physical Science	1, 3, 4, 5, 14, 15, 16, 17
Biological Science	2, 12, 13, 19, 20
E. Know the scientific enterprise	
Unclassified	6
II. Understand and apply the fundamental aspects of science in a wide range of problem situations	
A. Understand and apply facts and simple concepts	
Physical Science	7
D. Understand and apply inquiry skills	
Physical Science	9, 10, 11
Biological Science	8, 18

Judgment vs. Perception (J or P)

Scoring. Answer sheets may be machine-scored or hand scored (as done in this study). When scored by hand, eight separate keys are used to determine total points for each preference. Individual items carry point values of either one or two. The higher score of a given preference purports to represent the preferred process of that preference, while the difference between scores represents the strength of the preference. One point is either added to or subtracted from the latter score to eliminate possible zero scores. Continuous scores are obtained by adding 100 to I, N, F, and P strength scores or by subtracting E, S, T, and J strength scores from 100. An example of the scoring summary table used for each student is illustrated in Figure 2.

Reliability. By applying the Spearman-Brown Prophecy Formula to the MBTI, Myers (1962a) reported split-half reliabilities ranging from 0.70 to 0.94 on all four indices, with the exception of 0.44 and 0.60 on the TF index of underachieving eighth-graders and a non-prep twelfth-grade sample. Myers (1962a) suggests that "... the relative uncertainty on TF may reflect a lesser development of the judging process ..." (p. 20) of these two groups. The split-half reliabilities were reported for ten samples covering 727 subjects.

	Points		Points	Score	Con. Score
E	6	I	18	19	119
S	15	N	3	23	123
T	13	F	8	11	89
J	6	P	22	33	133

TYPE

I	N	T	P

Figure 2. MBTI Scoring Summary Table

In reviewing the MBTI, Sundberg (1965) noted that Myers (1962a) reported only internal consistencies, i.e., split-half reliabilities. However, he indicated that Myers' (1962a) "... figures are comparable to those of leading personality inventories" (p. 323).

However, at least two different studies have been conducted in which test-retest reliability coefficients were determined for continuous scores of the four scales of the MBTI. Stricker and Ross (1964), conducting a rather long fourteen-month test-retest interval, reported test-retest reliability coefficients ranging from 0.69 to 0.73 for the EI, SN, and JP scales, and 0.48 for the TF scale. Carskadon (1977), using an eight-week test-retest interval, reported test-retest reliability coefficients ranging from 0.73 to 0.87 on all scales, except 0.56 on the TF scale for males.

In addition, Stricker and Ross (1962) have indicated that the scales on the Gray-Wheelwright Physicological Type Questionnaire, corresponding to the MBTI scales EI, SN, and TF were 0.79, 0.58, and 0.60 respectively. The Gray-Wheelwright Psychological Type Questionnaire was developed independently of and for the same purpose as the MBTI but does not determine a JP preference.

Myers (1962a) has indicated that the reliabilities reported in the Manual "... appear creditable for an

instrument of this sort ..." (p. 20), viz., the MBTI. Her statement would seem to be supported by the studies of Stricker and Ross (1962, 1964) and Carskadon (1977).

Validity. The striking correlations between the MBTI and Gray-Wheelwright Psychological Type Questionnaire would tend to indicate that both items were measuring the same phenomena. According to Guilford (1954), "If complete correction for attenuation gives a coefficient close to 1.0 (within sampling error), one should conclude that one has in X and Y essentially two forms of the same test" (p. 401). This would seem to be the case with the two instruments. As a matter of fact, Myers (1962a) points out that,

> This degree of agreement seems explicable in only two ways, one reasonable and the other not. The reasonable explanation is that both tests are reflecting the same basic realities, that is, the Jungian opposites which both were designed to reflect. If not, it must be assumed that not only did the authors of the Indicator miss their objective but so did the Jungian analysts Gray and Wheelwright in exactly the same ways, a coincidence which seems unlikely. (p. 22)

In addition, the MBTI shows strong correlations with instruments not based on Jungian theory, including the Strong Vocational Interest Blank, the Allport-Vernon-Lidnzey Study of Values, the Edwards Personal Preference Schedule and the Personality Research

Inventory (Myers, 1962a).

However, some experts believe that Myers (1962a) has failed to demonstrate construct validity for the MBTI, i.e., the test does not actually measure the personality types as Jung (1923) himself classified them. Mendelsohn (1965) has indicated that,

> The EI scales seem to measure extraversion-introversion in the popular sense rather than in a Jungian sense. The items have to do primarily with ease in and liking for interpersonal contact, the factor of interest in the inner world of ideas being unrepresented.

He continues,

> The items of the N scale seem to refer to a practical, conventional realistic attitude as opposed to one more idea and theory oriented, stressing originality, autonomy, and complexity.
> (Mendelsohn, 1965, p. 322)

Mendelsohn (1965) also made similar objections to the TF and JP scales, indicating that the MBTI measures only limited aspects of the underlying Jungian constructs. However, in spite of his objections to the MBTI, Mendelsohn (1965) has stated,

> While the weight of the evidence does not support several basic assertions about the MBTI, the reviewer nevertheless considers the instrument of considerable potential utility. This conclusion is based on the findings which indicate that type scores relate meaningfully to a wide range of

> variables including personality, ability, interest, value, aptitude and performance measures, academic choice, and behavior ratings ... Although there are better predictors available for particular tasks, few instruments appear to provide as much information as can be derived from the MBTI. It would seem useful, then, for personality research, and, given its relationships to measures of interest, value aptitude, and achievement, for academic counseling.
>
> (Mendelsohn, 1965, p. 322)

Sundberg (1965) also endorses the use of the MBTI. He has stated,

> Even if one does not accept the structural implications of Jungian theory or even the theory itself, the empirical relations of the inventory's scales can be studied. Purely as a potential research procedure for getting at individual differences in cognitive preferences, it would seem the Indicator would merit a great deal of attention from cognitive theorists.
>
> (Sundberg, 1965, p. 325)

Cognitive Preference Examination II

The Cognitive Preference Examination II (CPE-II) was developed by Ronald K. Atwood of the University of Kentucky. CPE-II differs from other cognitive preference tests in two ways. First, CPE-II is discipline-free, i.e., content is not limited to a particular discipline, e.g., biology, chemistry, or physics. Item content was drawn from general science (11 items), social science (11 items) and areas closely related to science and/or social science (5 items). Three distractors were also included, yielding a total of thirty items.

Second, the number of options was reduced from four to three. Because students who took the CPE-II during its development expressed difficulty in keeping four options clearly in mind while making their choice, "The fundamental principles option, judged to be generally less distinct that the other options, was eliminated from the four initially used by Heath" (Atwood, 1971, p. 273). Atwood (1971) has stated that, "While the three option preference test doesn't provide the quantity of information as four, the quality of information appears superior" (p. 275).

Reducing the number of options did not originate with Atwood (1971). Marks (1966) first suggested that a CPT be developed using two items, namely, memory of facts and the critical questioning of information. Williams (1975) used three options (memory, application and principles) on his CPT. Although Tamir (1978) is critical of CPT's which deviate from Heath's (1964) original conception, Atwood (1971) and Williams (1975) have indicated that their CPT's have a more utilitarian use than measuring the effectiveness of curriculum program objectives.

Scoring. The scoring of the CPE-II followed the procedure indicated by Atwood (1967-68). Because of their ipsative nature, the scores were used for classification purposes only. Hicks (1970) has pointed out that

an ipsative measurement category yields scores such that each score for an individual is dependent on his/her own scores on other variables, but is independent of, and not comparable with, the scores of other individuals.

Students were placed into one of three categories (memory-M. application-A, or questioning-Q) if they selected a minimum of 13 (one less than one-half the number of preference items) items of a given preference, while choosing any other preference on a maximum of 7 items. Students were also placed into categories on the basis of two preference scores: memory-application (MA), memory-questioning (MQ), and application-questioning (AQ), by selecting each of two preferences on a minimum of 10 items.

Reliability. Reliabilities of 0.77 (application), 0.70 (memory), and 0.74 (questioning), indicated by Pearson product-moment test-retest stability coefficients, were reported by Atwood (1971). Atwood (1971) also reported reliabilities of 0.87 (application), 0.80 (memory), and 0.84 (questioning) by applying the Spearman-Brown Prophecy Formula. Atwood (1971) has indicated that reliabilities of this type appear to be adequate. Guilford (1965) has indicated that a narrow range of scores generally tends to lower reliability coefficients.

Validity. The items on the CPE-II were judged to be valid by a panel of judges composed of one person in science education, one person in social science education, and one person in educational research.

Instrument Modification. Because Atwood (1971) indicated that the CPE-II was developed for use by senior high level students, the CPE-II was examined by a reading consultant at the School of Education of The University of Michigan, to determine the feasibility of its use with junior high school students. The reading consultant indicated that it was difficult to determine the reading level of an instrument such as the CPE-II, which contains a large number of technical science words.

Therefore, the CPE-II was given to a group of 23 eighth-grade junior high school students. In addition to responding to the items on the test, each student was instructed to circle any words that s/he did not understand. These students ranged from the gifted to the underachiever.

As a result of this testing and with the consent of Professor Atwood, a number of words were changed which did not alter the meaning of any item. Womer (1979) has indicated that the reliability and validity of an item would not be significantly affected by altering the words in a given item, unless the item was used for comparison

with national norms. This modified CPE-II (see Appendix D) was then given to another group of eighth-grade students (N=26), with no problems reported to this investigator.

Five junior high/middle school science and social science teachers examined the modified CPE-II. Although they agreed that the CPE-II was acceptable for use by eighth-grade students, all offered a similar caveat: Many junior high schools students might not recall content material on the CPE-II, just as they might have difficulty remembering material on teacher-prepared tests. This, of course, would present a problem with any type of test requiring familiarity with content. However, only one student in the pilot study indicated that he did not know or remember the content on the CPE-II (this student being mainstreamed into the regular academic program).

Science and Scientist Attitude Inventory

The Science and Scientist Attitude Inventory (SASAI) was developed by Lamoine L. Motz (1970) to determine the attitudes of students toward science and scientists. Students were asked to respond (agree-disagree-undecided) to 21 statements about science (Part I) and to 29 statements about scientists (Part II).

Scoring. The students' responses on the SASAI were scored against the responses made by the professional control group of twenty-five scientists, engineers and science educators. A separate score was computed for Part I (attitudes toward science) and Part II (attitudes toward scientists) of the SASAI.

Reliability. By using the Spearman-Brown Prophecy Formula, Motz (1970) reported reliabilities of 0.48 for Part I (attitudes toward science) and 0.78 for Part II (attitudes toward scientists) of the SASAI.

Validity. A group of twenty-five professional scientists, engineers and science educators were asked to respond to the statements that appear on the SASAI. Each statement represents a minimum two-thirds agreement in response (i.e., agreement, disagreement, undecided) among the professional group.

Intelligence Quotient Score

The schools participating in this study did not give traditional "I.Q." tests. However, Womer (1979) and Ebel (1972) have indicated that an I.Q. score is essentially a measurement of vocabulary meaning. Therefore, the vocabulary score for each student from Form D of the Gates-MacGinitie Reading Tests was provided by the schools. The Technical Manual (1965) of the

Gates-MacGinitie Reading Tests indicates a correlation of 0.77 between the vocabulary scores of the test (Form D) and the Lorge-Thorndike Verbal I.Q.

Using the conversion factor indicated by Womer (1979), each vocabulary score was converted to a Z-score and multiplied by 15. If the Z-score was positive, the converted Z-score was added to 100 to obtain the derived I.Q. score. If the Z-score was negative, the converted Z-score was subtracted from 100 to obtain the derived I.Q. score.

Ebel (1972) and Noll and Scannel (1972) have indicated that an I.Q. score of 100 may be considered as "normal average." I.Q.'s above 100 were considered to be "high" and below 100 to be "low" for certain analyses in this study.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF THE DATA

This chapter is divided into two major sections: the analysis of the sample used in this study and the analysis and interpretation of the data. The analysis of the sample is divided into two parts: an analysis according to Myers-Briggs Type Indicator (MBTI) personality types and an analysis according to cognitive preference orientation (CPO).

Analysis of the Sample

MBTI Analysis of the Sample

Two hundred and seventy-one students completed the MBTI. The preferences and type were determined for each student as described in Chapter III. Since the type distribution reported by D. C. May (1971) was so similar to the sample used in this study, a chi-square analysis was employed to determine if there was any significant difference between them.

The chi-square (χ^2) test is a simple and useful statistical technique for comparing frequency data obtained in an experiment to data that would be expected on the basis of an hypothesis. Comparisons are made between the expected (independent values) frequencies

and the observed (actual values) frequencies for each case. If the hypothesis is tenable, the difference between observed and expected frequencies should be no larger than that which would arise by chance. If the difference is too large, that is, not apt to arise by chance alone, then the null hypothesis of independence becomes suspect. A significant chi-square value leads one to suspect that there is some degree of relationship (association) between variables, i.e., the rows and columns in a contingency table are not independent.

Using May's (1971) type distribution as the expected frequencies, the chi-square values presented in Table 5 were not significant at the .05 level of significance. Thus, the 1971 Florida, eighth-grade junior high school students are not significantly different from the 1979 Michigan, eighth-grade junior high school students when the sixteen individual MBTI personality types are considered.

A chi-square analysis was also employed to determine if the major MBTI personality preferences EI, SN, TF, and JP were significantly different from the type distribution reported by May (1971). The chi-square values presented in Table 6 are not significant at the .05 level of significance. This analysis supports the previous analysis that the two MBTI populations of junior high school students are similar.

TABLE 5

COMPARISON OF THE FREQUENCY DISTRIBUTIONS OF THE SIXTEEN INDIVIDUAL MBTI PERSONALITY TYPES IN THIS STUDY TO D.C. MAY'S 1971 DOCTORAL STUDY

	SENSING TYPES		INTUITIVE TYPES		
	with THINKING	with FEELING	with FEELING	with THINKING	
INTROVERTS JUDGING	**ISTJ** May Novak N = 12 12 % = 4.07 4.43 I = 1.09 χ^2 = 0.05	**ISFJ** May Novak N = 31 21 % = 10.51 7.75 I = 0.74 χ^2 = 1.29	**INFJ** May Novak N = 6 11 % = 2.03 4.06 I = 2.00 χ^2 = 1.99	**INTJ** May Novak N = 1 4 % = 0.34 1.48 I = 4.35 FEP = 0.20	
INTROVERTS PERCEPTIVE	**ISTP** May Novak N = 20 14 % = 6.78 5.17 I = 0.76 χ^2 = 0.65	**ISFP** May Novak N = 19 26 % = 6.44 9.59 I = 1.49 χ^2 = 1.92	**INFP** May Novak N = 26 19 % = 8.81 7.01 I = 0.80 χ^2 = 0.63	**INTP** May Novak N = 8 11 % = 2.71 4.06 I = 1.50 FEP = 0.79	
EXTRAVERTS PERCEPTIVE	**ESTP** May Novak N = 13 17 % = 4.41 6.27 I = 1.42 χ^2 = 0.98	**ESFP** May Novak N = 40 44 % = 13.56 16.24 I = 1.20 χ^2 = 0.80	**ENFP** May Novak N = 36 30 % = 12.20 11.07 I = 0.91 χ^2 = 0.18	**ENTP** May Novak N = 5 11 % = 0.83 4.06 I = 2.39 FEP = 0.13	
EXTRAVERTS JUDGING	**ESTJ** May Novak N = 22 19 % = 7.46 7.01 I = 0.94 χ^2 = 0.04	**ESFJ** May Novak N = 35 21 % = 11.86 7.75 I = 0.65 χ^2 = 2.68	**ENFJ** May Novak N = 14 8 % = 4.75 2.95 I = 0.62 χ^2 = 1.22	**ENTJ** May Novak N = 7 3 % = 2.37 1.11 I = 0.47 FEP = 0.34	

I = Self-Selection Index: ratio of percent of type in this study to percent of type in May's (1971) study.

FEP = Fisher's Exact Probability used instead of chi-square.

TABLE 6

ANALYSIS OF THE FREQUENCY DISTRIBUTIONS OF THE EI, SN, TF, AND JP[a] MBTI PERSONALITY TYPES IN D.C. MAY'S 1971 DOCTORAL STUDY AND IN THIS STUDY

Personality Type	May - 1971		Novak - 1979		I[b]	Chi-Square
E	172	58.31%	153	56.46%	0.97	0.20
I	123	41.69%	118	43.54%	1.04	0.20
S	192	65.08%	174	64.21%	0.99	0.05
N	103	34.92%	97	35.79%	1.03	0.05
T	88	29.83%	88	33.58%	1.13	0.92
F	207	70.17%	180	66.42%	0.95	0.92
J	128	43.39%	99	36.53%	0.84	2.77
P	167	56.61%	172	63.47%	1.12	2.77

[a]E - Relates more easily to the outer world of actions, objects and persons than to the inner world of concepts and ideas.

I - Relates more easily to the inner world of ideas and concepts than to the outer world of actions, objects and persons.

S - Would rather work with known facts than look for possibilities, relationships and inferred meanings.

N - Would rather look for possibilities, relationships and inferred meanings than work with known facts.

T - Bases judgments more on impersonal analysis, logical order, and cause and effect than on personal importance and values.

F - Bases judgments more on personal importance and values than on impersonal analysis, logical order, and cause and effect.

J - Likes a planned, decided, orderly life style better than a flexible, spontaneous life style.

P - Likes a flexible, spontaneous life style better than a planned, decided, orderly life style.

[b]I - Self-selection index: ratio of percent of type in group to percent in sample.

As seen in Table 6, the ratios of types in this study are approximately:

1 E-Extravert	(56.5%)	to 1	I-Introvert	(43.5%)
2 S-Sensing	(64.2%)	to 1	N-Intuitive	(35.8%)
1 T-Thinking	(33.6%)	to 2	F-Feeling	(66.4%)
1 J-Judging	(36.5%)	to 2	P-Perceiving	(63.5%)

These ratios are similar to those reported by May (1971) as seen in Table 6.

Barberousse (1965) reported that 71% of her eighth-grade junior high school sample was sensing and 29% intuitive. Likewise, Myers (1962a) reported 72% sensing and 28% intuitive for male and 70% sensing and 30% intuitive for female seventh- and eighth-grade junior high school students. These values are similar to the values determined in this study.

Although there tend to be slightly more extraverts than introverts in this study, Myers (1962a) reported a 3:1 ratio of extraverts to introverts among her junior high school sample (pre-college preparatory students). Whereas Myers (1962a) found the JP ratio to be approximately 1:1, the JP ratio in this study is approximately 1:2. Since it is difficult to make any generalization concerning TF ratios without taking the sex of the individual into account, this aspect of the analysis of the sample will be reserved for consideration in a later chapter.

In summary, the sample of eighth-grade junior high school students in this study is similar to samples used in other studies when MBTI personality types are considered.

CPO Analysis of the Sample

Two hundred and seventy-eight students completed the CPE-II. Scoring followed the procedure described in Chapter III.

As seen in Table 7, 14 students were classified as M, 34 were classified as A, and 10 were classified as Q. No definite preferences would be detected for 220 students. When grouped according to two preferences, 112 were classified as MA, 58 were classified as MQ, and 60 were classified as AQ. No definite preference could be detected for 48 students when a two-preference classification was used. Students who demonstrated no definite preference invariably selected items resulting in an equal spread, i.e., 9-M, 9-A, and 9-Q.

Although the number of students who exhibited a single, determinable preference was low, the result was not entirely unexpected. Testing 775 students with his high school chemistry cognitive preference test, Atwood (1967-68) reported 4-M, 9-A, 31-Q, and 29-P. As in this study, Atwood's (1967-68) numbers increased when a two-preference classification was used.

TABLE 7

CLASSIFICATION OF STUDENTS ACCORDING TO THEIR COGNITIVE PREFERENCE ORIENTATION M, A, Q AND MA, MQ, AQ[a]

Cognitive Preference Orientation	N	%
M	14	5.0
A	34	12.3
Q	10	3.6
NP[b]	220	79.1
Total	278	100.0
MA	112	40.3
MQ	58	20.8
AQ	60	21.6
NP[b]	48	17.3
Total	278	100.0

[a]M - Prefers to recall information.
A - Prefers information in view of its applicability.
Q - Prefers to question or challenge information.

[b]NP - No detectable preference.

Data Analysis and Interpretation

Fourteen null hypotheses were formulated and tested at the .001 level of significance to answer the eight questions proposed in the first chapter of this study. Since a large number of individual statistical tests were performed in this study, the .001 level of significance was selected to reduce the chance of making a Type I error. A Type I error is made when a true null hypothesis is rejected.

The eight questions proposed in Chapter I are repeated as a guide in the analysis and interpretation of the data.

Question 1

Do eighth-grade science students classified according to their MBTI personality types differ in their cognitive preference orientation?

Hypothesis 1: There is no statistical significant relationship between MBTI personality types and cognitive preference orientation.

It was predicted that the MBTI personality types I, N, T, and P would prefer questioning (Q), application (A), or application-questioning (AQ) responses on the CPE-II. Likewise, the MBTI personality types E, S, F, and J would prefer memory (M), memory-application (MA), or

memory-questioning (MQ) responses on the CPE-II. This prediction was not supported by the chi-square analyses presented in Tables 8-11. In addition, the contingency coefficients associated with the chi-square values are extremely low. The contingency coefficient (cc) is a measure of the strength of a relationship between two variables using frequency data.

The chi-square values of 0.85 and 2.56 for EI, 0.36 and 3.05 for SN, 0.27 and 0.49 for TF, and 0.54 and 0.40 for JP (see Tables 8-11) are not significant. Thus, there appears to be no significant relationship between MBTI personality types and cognitive preference orientation. Any differences observed would be due to chance.

Although no significant relationships were detected between cognitive preference orientation and the major MBTI personality types, chi-square analyses were used to determine if any relationships existed between the SNTF, EISN, and SNJP of the MBTI personality type groups and the cognitive preference orientation of the students in this study. The results of these analyses are presented in Tables 12 to 14.

The chi-square values of 1.44 and 4.51 for SNTF (Table 12), 2.10 and 13.39 for EISN (Table 13), and 2.16 and 4.73 for SNJP (Table 14) are also not significant.

TABLE 8

ANALYSIS OF MBTI PERSONALITY TYPES EI[a]
ACCORDING TO COGNITIVE PREFERENCE ORIENTATION
M, A, Q, AND MA, MQ, AQ[b]

Personality Types	Cognitive Preference Orientation Observed Frequencies			
	M (%)	A (%)	Q (%)	Total (%)
E	6 (42.9)	17 (50.0)	3 (33.3)	26 (33.3)
I	8 (57.1)	17 (50.0)	6 (66.7)	31 (54.4)
Total	14 (24.5)	34 (59.6)	9 (15.9)	57(100.0)
$\chi^2 = 0.85$	cc = 0.12			

	MA (%)	MQ (%)	AQ (%)	Total (%)
E	61 (55.5)	37 (63.8)	29 (49.2)	127 (55.9)
I	49 (44.5)	21 (36.2)	30 (50.8)	100 (44.1)
Total	110 (48.5)	58 (25.5)	59 (26.0)	227(100.0)
$\chi^2 = 2.56$	cc = 0.11			

[a] E - Relates more easily to the outer world of actions, objects and persons than to the inner world of concepts and ideas.

I - Relates more easily to the inner world of concepts and ideas than to the outer world of actions, objects and persons.

[b] M - Prefers to recall information.

A - Prefers information in view of its applicability.

Q - Prefers to question or challenge information.

TABLE 9

ANALYSIS OF MBTI PERSONALITY TYPES SN[a]
ACCORDING TO COGNITIVE PREFERENCE ORIENTATION
M, A, Q AND MA, MQ, AQ[b]

Personality Types	Cognitive Preference Orientation Observed Frequencies							
	M	(%)	A	(%)	Q	(%)	Total	(%)
S	10	(71.4)	23	(67.7)	7	(77.8)	40	(70.2)
N	4	(28.6)	11	(32.4)	2	(22.2)	17	(29.8)
Total	14	(24.5)	34	(59.6)	9	(15.9)	57	(100.0)
χ^2 = 0.36	cc = 0.08							
	MA	(%)	MQ	(%)	AQ	(%)	Total	(%)
S	65	(59.1)	42	(72.4)	39	(66.1)	146	(64.3)
N	45	(40.9)	16	(27.6)	20	(33.9)	31	(35.7)
Total	110	(48.5)	58	(25.5)	59	(26.0)	227	(100.0)
χ^2 = 3.05	cc = 0.12							

[a] S - Would rather workd with known facts that look for possibilities, relationships and inferred meanings.

N - Would rather look for possibilities, relationships and inferred meanings than work with known facts.

[b] M - Prefers to recall information.

A - Prefers information in view of its applicability.

Q - Prefers to question or challenge information.

TABLE 10

ANALYSIS OF MBTI PERSONALITY TYPES TF[a]
ACCORDING TO COGNITIVE PREFERENCE ORIENTATION
M, A, Q AND MA, MQ, AQ[b]

Personality Types	Cognitive Preference Orientation Observed Frequencies							
	M	(%)	A	(%)	Q	(%)	Total	(%)
T	5	(35.7)	12	(35.3)	4	(44.5)	21	(36.8)
F	9	(64.3)	22	(64.7)	5	(55.6)	36	(63.2)
Total	14	(24.5)	34	(59.6)	9	(15.9)	57	(100.0)
$\chi^2 = 0.27$	cc = 0.07							
	MA	(%)	MQ	(%)	AQ	(%)	Total	(%)
T	35	(31.8)	21	(36.2)	18	(30.5)	74	(32.6)
F	75	(68.2)	37	(63.8)	41	(69.5)	153	(67.4)
Total	110	(48.5)	58	(25.5)	59	(26.0)	227	(100.0)
$\chi^2 = 0.49$	cc = 0.05							

[a] T - Bases judgments more on impersonal analysis, logical order, and cause and effect than on personal importance and values.

F - Bases judgments more on personal importance and values than on impersonal analysis, logical order, and cause and effect.

[b] M - Prefers to recall information.

A - Prefers information in view of its applicability.

Q - Prefers to question or challenge information.

TABLE 11

ANALYSIS OF MBTI PERSONALITY TYPES JP[a]
ACCORDING TO COGNITIVE PREFERENCE ORIENTATION
M, A, Q AND MA, MQ, AQ[b]

Personality Types	Cognitive Preference Orientation Observed Frequencies M	(%)	A	(%)	Q	(%)	Total	(%)
J	6	(42.9)	14	(41.2)	2	(22.2)	22	(38.6)
P	8	(57.1)	20	(58.8)	7	(77.8)	35	(61.4)
Total	14	(24.5)	34	(59.6)	9	(15.9)	57	(100.0)
χ^2 = 0.54	cc = 0.14							

	MA	(%)	MQ	(%)	AQ	(%)	Total	(%)
J	41	(37.3)	22	(34.5)	22	(40.7)	85	(37.4)
P	69	(62.7)	36	(65.5)	37	(59.3)	142	(62.6)
Total	110	(48.5)	58	(25.5)	59	(26.0	227	(100.0)
χ^2 - 0.40	cc = 0.05							

[a]J - Likes a planned, decided, orderly life style better than a flexible, spontaneous life style.

P - Likes a flexible, spontaneous life style better than a planned, decided, orderly life style.

[b]M - Prefers to recall information.

A - Prefers information in view of its applicability.

Q - Prefers to question or challenge information.

TABLE 12

ANALYSIS OF THE SENSING AND INTUITIVE MBTI PERSONALITY TYPES WITH THINKING AND FEELING (SNTF[a]) ACCORDING TO COGNITIVE PREFERENCE ORIENTATION M, A, Q AND MA, MQ, AQ[b]

Cognitive Preference Orientation	Personality Type Groups Observed Frequencies ST	(%)	SF	(%)	NF	(%)	NT	(%)	Total	(%)
M	4	(23.1)	6	(23.1)	3	(30.0)	1	(30.0)	14	(24.6)
A	7	(50.0)	16	(65.1)	6	(60.0)	5	(71.4)	34	(59.6)
Q	3	(21.4)	4	(15.4)	1	(10.0)	1	(14.3)	9	(15.8)
Total	14	(24.6)	26	(45.6)	10	(17.5)	7	(12.3)	57	(100.0
χ^2 = 1.44	cc = 0.16									
MA	21	(42.0)	44	(45.8)	31	(54.4)	14	(58.3)	110	(48.5)
MQ	15	(30.0)	27	(28.1)	10	(17.5)	6	(15.0)	58	(15.6)
AQ	14	(28.0)	25	(26.0)	16	(28.1)	4	(16.7)	59	(26.0)
Total	50	(22.0)	96	(42.3)	57	(25.1)	24	(10.6)	227	(100.0)
χ^2 = 4.51	cc = 0.14									

[a]ST - "Pratical and matter-of-fact": Prefer to work with known facts and make judgments based on impersonal analysis, logical order and cause and effect.

SF - "Sympathetic and friendly": Prefer to work with known facts and make judgments based on personal importance and values.

NF - "Enthusiastic and insightful": Prefer to look for possibilities, relationships and inferred meanings of experiences and make judgments based on personal importance and values.

NT - "Logical and ingeneous": Prefer to look for possibilities, relationships and inferred meanings of experiences and make judgments based on impersonal analysis, logical order, and cause and effect.

[b]M - Prefers to recall information.

A - Prefers information in view of its applicability.

Q - Prefers to question or challenge information.

TABLE 13

ANALYSIS OF THE EXTRAVERT AND INTROVERT MBTI PERSONALITY TYPES WITH SENSING AND INTUITION (EISN[a]) ACCORDING TO COGNITIVE PREFERENCE ORIENTATION M, A, Q AND MA, MQ, AQ[b]

Cognitive Preference Orientation	Personality Type Groups Expected Frequencies IN	(%)	EN	(%)	IS	(%)	ES	(%)	Total	(%)
M	3	(27.3)	1	(16.7)	5	(25.0)	5	(15.0)	14	(24.6)
A	6	(54.5)	5	(83.8)	11	(55.0)	12	(60.0)	34	(59.6)
Q	2	(18.2)	0	(0.0)	4	(20.0)	3	(15.0)	9	(15.8)
Total	11	(19.3)	6	(10.5)	20	(35.1)	20	(35.1)	57	(100.0)
χ^2 = 2.10	cc = 0.19									
MA	18	(47.4)	27	(62.8)	31	(50.0)	34	(40.5)	110	(48.5)
MQ	10	(26.3)	6	(14.0)	11	(17.7)	31	(36.9)	58	(25.6)
AQ	10	(26.3)	10	(23.3)	20	(32.3)	19	(22.6)	59	(26.0)
Total	38	(16.8)	43	(18.9)	62	(27.3)	84	(37.0)	227	(100.0)
χ^2 = 13.39	cc = 0.23									

[a] IN - Relates easily to the inner world of ideas and concepts and prefers to look for possibilities, relationships and inferred meanings of experiences.

EN - Relates easily to the outer world of actions, objects and persons and prefers to look for possibilities, relationships and inferred meanings of experiences.

IS - Relates easily to the inner world of ideas and concepts and prefers to work with known facts.

ES - Relates easily to the outer world of actions, objects and persons and prefers to work with known facts.

[b] M - Prefers to recall information.

A - Prefers information in view of its applicability.

Q - Prefers to question or challenge information.

TABLE 14

ANALYSIS OF THE SENSING AND INTUITIVE MBTI PERSONALITY TYPES WITH JUDGING AND PERCEIVING (SNJP[a]) ACCORDING TO COGNITIVE PREFERENCE ORIENTATION M, A, Q AND MA, MQ, AQ[b]

Cognitive Preference Orientation	Personality Type Groups Expected Frequencies									
	SJ	(%)	SP	(%)	NP	(%)	NJ	(%)	Total	(%)
M	5	(29.4)	5	(21.7)	3	(25.0)	1	(20.0)	14	(24.6)
A	10	(58.8)	13	(56.5)	7	(58.3)	4	(80.0)	34	(59.6)
Q	2	(11.8)	5	(21.7)	2	(16.7)	0	(0.0)	9	(15.8)
Total	17	(29.8)	23	(40.4)	12	(21.1)	5	(8.7)	57	(100.0)
$\chi^2 = 2.16$ cc = 0.19										
MA	28	(45.9)	37	(43.5)	33	(57.9)	12	(50.0)	110	(48.5)
MQ	16	(26.2)	26	(30.6)	12	(21.1)	4	(16.7)	58	(25.6)
AQ	17	(27.9)	22	(25.9)	12	(21.1)	8	(33.3)	59	(26.0)
Total	61	(26.9)	85	(37.4)	57	(25.1)	24	(10.6)	227	(100.0)
$\chi^2 = 4.73$ cc = 0.14										

[a] SJ - Prefers to work with facts and likes a planned, decided, orderly life style.

SP - Prefers to work with facts and likes a flexible, spontaneous life style.

NP - Prefers to look for possibilities, relationships and inferred meanings of experiences and likes a flexible, spontaneous life style.

NJ - Prefers to look for possibilities, relationships and inferred meanings of experiences and likes a planned, decided, orderly life style.

[b] M - Prefers to recall information.

A - Prefers information in view of its applicability.

Q - Prefers to question or challenge information.

These results indicate that there is no significant relationship between MBTI personality type groups and cognitive preference orientation. Any differences observed would be due to chance alone.

Because no significant relationships could be demonstrated between MBTI personality types or type groups and cognitive preference orientation, Hypothesis 1 is not rejected.

Question 2

Is there a difference in intelligence between eighth-grade science students classified according to their MBTI personality types and cognitive preference orientation?

Hypothesis 2. There is no statistically significant difference between mean intelligence scores of the MBTI personality types.

Individual intelligence scores of the students ranged from 65 to 137 with a mean of 99.9. The intelligence scores of the sixteen individual MBTI personality types are presented in Table 15.

EI, SN, TF, and JP MBTI Personality Types. The analysis of variance was used to analyze the differences between the mean intelligence scores of the EI, SN, TF, and JP MBTI personality types. The results of these

TABLE 15

MEAN INTELLIGENCE SCORES OF THE SIXTEEN INDIVIDUAL MBTI PERSONALITY TYPES

	SENSING TYPES with THINKING	SENSING TYPES with FEELING	INTUITIVE TYPES with FEELING	INTUITIVE TYPES with THINKING	
	ISTJ	*ISFJ*	*INFJ*	*INTJ*	JUDGING
	N = 12 % = 4.43	N = 21 % = 7.75	N = 11 % = 4.06	N = 4 % = 1.48	
Mean	93.18	92.62	91.55	117.25	
SD	14.22	13.68	11.64	16.64	
	ISTP	*ISFP*	*INFP*	*INTP*	PERCEPTIVE
	N = 14 % = 5.17	N = 26 % = 9.59	N = 19 % = 7.01	N = 11 % = 4.06	
Mean	92.64	96.62	111.11	112.56	
SD	14.64	11.83	13.58	14.98	
	ESTP	*ESFP*	*ENFP*	*ENTP*	PERCEPTIVE
	N = 17 % = 6.27	N = 44 % = 16.24	N = 30 % = 11.07	N = 11 % = 4.06	
Mean	104.47	98.82	105.90	109.09	
SD	16.03	12.48	15.99	11.80	
	ESTJ	*ESFJ*	*ENFJ*	*ENTJ*	JUDGING
	N = 19 % = 7.01	N = 21 % = 7.75	N = 8 % = 2.95	N = 3 % = 1.11	
Mean	95.63	94.67	99.63	104.00	
SD	14.10	14.27	14.41	4.58	

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analyses are presented in Table 16.

Barron (1974) has succinctly described this statistical technique.

> If the means of ... subgroups are greatly different, the variance of the combined groups is much larger than the variance of the spearate groups. The analysis of differences in means is based on this fact. The analysis of variance rests on a separation of the variance of all the observations into parts, each of which measures variability attributable to some specific sources. This is a breakdown of the sample variance and is a powerful parametric test. The basic principle of this test is to determine whether the sample means vary further from the population mean than we should expect, in view of the variations of single cases from the same mean.
>
> The heart of ... analysis of variance lies in the following fact: If the groups are random samples from the same population, the two variances, within and between, are unbiased estimates of the same population variance. It then tests for the significance of the differences of the two types by use of the F test. If F is sufficiently large, the null hypotheses become suspect, and we draw a positive conclusion, the nature of which depends on the given situation.
>
> (Barron, 1974, pp. 40-41)

The F-ratios of 0.78 for the EI MBTI personality types and 1.11 for the TF MBTI personality types indicate that there are no significant differences between the mean intelligence scores of introverts and extraverts, and between the mean intelligence scores of thinking and feeling students.

The significant F-ratios of 28.89 for the SN MBTI personality types and 15.12 for the JP MBTI personality

TABLE 16

ANALYSIS OF VARIANCE OF THE INTELLIGENCE SCORES FOR THE EI, SN, TF AND JP[d] MBTI PERSONALITY TYPES

Personality Types	N	Mean	Standard Deviation	F-ratio
E	153	100.75	14.52	0.78
I	118	99.13	15.67	
S	174	96.56	13.77	28.89***
N	97	106.30	15.23	
T	91	101.40	15.96	1.11
F	180	99.36	14.53	
J	99	95.49	14.38	15.12***
P	172	102.67	14.85	

***$p \leq .001$

[a]E - Relates more easily to the outer world of actions, objects and persons than to the inner world of concepts and ideas.

I - Relates more easily to the inner world of ideas and concepts than to the outer world of actions, objects and persons.

S - Would rather work with known facts than look for possibilit-es, relationships and inferred meanings of experiences.

N - Would rather look for possibilities, relationships and inferred meanings of experiences than work with known facts.

T - Bases judgments more on impersonal analysis, logical order, and cause and effect than on personal importance and values.

F - Bases judgments more on personal importance and values than on impersonal analysis, logical order, and cause and effect.

J - Likes a planned, decided, orderly life style better than a flexible, spontaneous life style.

P - Likes a flexible, spontaneous life style better than a planned, decided, orderly life style.

types, indicate that the differences between the means of the sensing and intuitive students, and between the means of the judging and perceptive students are greater than what would be expected by chance alone. Thus, there is a real difference between intelligence of the sensing and intuitive students, and between the judging and perceptive students. Intuitive students have a higher mean intelligence score than do sensing students. Perceiving students have a higher mean intelligence score than do judging students.

SNTF MBTI Personality Type Groups. An analysis of variance was used to determine if the mean intelligence scores of the SNTF MBTI personality type groups were significantly different from each other. The significant F-ratio of 11.24, obtained from this analysis of variance, indicates that there is a significant difference between the mean intelligence scores of the SNTF MBTI personality type groups (see Table 17). This difference is greater than what would be expected by chance.

However, it is difficult to make valid judgments simply by comparing the mean scores of more than two groups used in the analysis of variance. Consequently, in order to make a valid interpretation of the nature of the differences between the means following a significant F-ratio, the Newman-Keuls procedure for pairwise

TABLE 17

ANALYSIS OF VARIANCE OF THE MEAN INTELLIGENCE SCORES OF THE SENSING AND INTUITIVE MBTI PERSONALITY TYPES WITH THINKING AND FEELING
SNTF[a]

Personality Type Groups	N	Mean	Standard Deviation	F-ratio
ST	62	96.90	15.22	
SF	112	96.37	12.96	11.24***
NF	68	104.29	15.68	
NT	29	111.00	13.20	

***$p \leq .001$

[a]ST - "Practical and matter-of-fact": Prefer to work with known facts and make judgments based on impersonal analysis, logical order, and cause and effect.

SF - "Sympathetic and friendly": Prefer to work with known facts and make judgments based on personal importance and values.

NF - "Enthusiastic and insightful": Prefer to look for possibilities, relationships and inferred meanings of experiences and make judgments based on personal importance and values.

NT - "Logical and ingeneous": Prefer to look for possibilities, relationships and inferred meanings of experiences and make judgments based on impersonal analysis, logical order, and cause and effect.

comparisons was employed (Winer, 1971). The Newman-Keuls procedure seeks to determine where the actual differences are.

The Newman-Keuls procedure was selected since six simple (individual) contrasts were involved in the post hoc analysis. Yeany (1978) suggests that the Newman-Keuls procedure is the best "all-round test" for post hoc comparisons, although it is not the most conservative. The .01 and .05 levels of significance used in the Newman-Keuls procedure are considered acceptable since the F-ratio obtained from the analysis of variance is significant at the .001 level of significance.

As seen in Table 18, there are significant differences between the means of the ST-NF, ST-NT, NF-ST, and NT-SF MBTI personality type groups such that,

NT (111.00) > ST (96.90)
NF (104.29) > ST (96.90)
NF (111.00) > SF (96.37)
NT (111.00) > SF (96.37)
NT (111.00) > NF (104.29)

An examination of the above rankings indicates that the mean intelligence scores of the intuitive students are significnatly higher than the mean intelligence scores of the sensing students. Furthermore, this difference is not associated with the TF preference, except when intuition alone is considered. The intelligence scores of

TABLE 18

PAIRWISE COMPARISONS OF THE MEAN INTELLIGENCE SCORES OF THE SENSING AND INTUITIVE MBTI PERSONALITY TYPES WITH THINKING AND FEELING USING THE NEWMAN KEULS PROCEDURE

SNTF[a]

Group	Mean	Differences			
NT	111.00	0.0			
NF	104.29	6.71**	0.0		
ST	96.90	14.10**	7.39**	0.0	
SF	96.37	14.63**	7.93**	0.54	0.0
		111.00	104.29	96.90	96.37
		NT	NF	ST	SF
r =		4	3	2	
r (.05)		3.36	3.31	2.77	
r (.01)		4.40	4.12	3.64	
q = 1.23					
q (.05)*		6.28	5.72	4.79	
q (.01)**		7.61	7.13	6.30	

*$p \leq .05$

**$p \leq .01$

[a]ST - "Practical and matter-of-fact": Prefer to work with known facts and make judgments based on impersonal analysis, logical order, and cause and effect.

SF - "Sympathetic and friendly": Prefer to work with known facts and make judgments based on personal importance and values.

NF - "Enthusiastic and insightful": Prefer to look for possibilities, relationships and inferred meanings of experiences and make judgments based on personal importance and values.

NT - "Logical and ingeneous": Prefer to look for possibilities, relationships and inferred meanings of experiences and make judgments based on impersonal analysis, logical order, and cause and effect.

intuitives with thinking (NT) are significantly higher than the intelligence scores of intuitives with feeling (NF).

EISN MBTI Personality Type Groups. The analysis of variance was used to determine if the means of the EISN MBTI personality type groups were significantly different from each other. The significant F-ratio of 11.03 obtained from this analysis of variance (see Table 19) indicates that there is a significant difference between the mean intelligence scores of the EISN MBTI personality type groups. This difference is greater than what would be expected by chance alone.

The Newman-Keuls procedure was again used to make a valid interpretation of the nature of the differences between these means. As seen in Table 20, there are significant differences between the means of the IN-IS, IN-ES, EN-IS, and EN-ES MBTI personality type groups such that,

IN (107.22) > IS (94.14)
IN (197.22) > ES (98.31)
EN (105.50) > IS (94.14)
EN (105.50) > ES (98.31)

Again, in all of the above rankings, the mean intelligence scores of the intuitive students are significantly higher than the mean intelligence scores of the sensing students.

TABLE 19

ANALYSIS OF VARIANCE OF THE MEAN INTELLIGENCE SCORES OF THE EXTRAVERT AND INTROVERT MBTI PERSONALITY TYPES WITH SENSING AND INTUITION
EISN[a]

Personality Type Groups	N	Mean	Standard Deviation	F-ratio
IN	45	107.22	16.13	
EN	52	105.50	14.51	11.03***
IS	73	94.14	13.18	
ES	101	98.31	13.98	

***$p \leq .001$

[a]IN - Relates easily to the inner world of ideas and concepts and prefers to look for possibilities, relationships and inferred meanings of experiences.

EN - Relates easily to the outer world of actions, objects and persons and prefers to look for possibilities, relationships and inferred meanings of experiences.

IS - Relates easily to the inner world of ideas and concepts and prefers to work with known facts.

ES - Relates easily to the outer world of actions, objects and persons and prefers to work with known facts.

TABLE 20

PAIRWISE COMPARISONS OF THE MEAN INTELLIGENCE SCORES OF THE EXTRAVERT AND INTROVERT MBTI PERSONALITY TYPES WITH SENSING AND INTUITION USING THE NEWMAN KEULS PROCEDURE

EISN[a]

Group	Mean	Differences			
IN	107.22	0.0			
EN	105.50	1.72	0.0		
ES	98.14	8.92**	7.19**	0.0	
IS	94.14	13.09**	11.36**	4.17	0.0
		107.22	105.50	98.14	94.14
		IN	EN	ES	IS
r =		4	3	2	
r (.05)		3.36	3.31	2.77	
r (.01)		4.40	4.12	3.69	
q = 1.73					
q (.05)*		6.28	5.72	4.79	
q (.01)**		7.61	7.13	6.30	

*$p \leq .05$

**$p \leq .01$

[a]IN - Relates easily to the inner world of ideas and concepts and prefers to look for possibilities, relationships and inferred meanings of experiences.

EN - Relates easily to the outer world of actions, objects and persons and prefers to look for possibilities, relationships and inferred meanings of experiences.

IS - Relates easily to the inner world of ideas and concepts and prefers to work with known facts.

ES - Relates easily to the outer world of actions, objects and persons and prefers to work with known facts.

In addition, these differences are not associated with an individual's EI preference.

SNJP MBTI Personality Type Groups. The analysis of variance was used to determine if the means of the SNJP MBTI personality type groups were significantly different from each other. The significant F-ratio of 14.15 obtained from this analysis of variance (see Table 21) indicates that there is a significant difference between the mean intelligence scores of the SNJP MBTI personality type groups. As in the previous analyses, this difference is greater than what would be expected by chance alone.

The Newman-Keuls procedure was used to determine where the differences were among the SNJP MBTI personality type groups. The results (presented in Table 22) indicate significant differences between NP-SJ, NP-SP, and NP-NJ such that,

NP (108.82) > SJ (94.08)
NP (108.82) > SP (98.35)
NP (108.82) > NJ (99.42)

These rankings indicate that intuitive students have significantly higher mean intelligence scores than do sensing students. In addition, perceptive students appear to have higher mean intelligence scores than do judging students. Students highest in mean intelligence scores are both intuitive and perceptive.

TABLE 21

ANALYSIS OF VARIANCE OF THE MEAN INTELLIGENCE SCORES OF THE SENSING AND INTUITIVE MBTI PERSONALITY TYPES WITH JUDGING AND PERCEIVING SNJP[a]

Personality Type Groups	N	Mean	Standard Deviation	F-ratio
SJ	73	94.08	13.81	
SP	101	98.35	13.52	14.15***
NP	71	108.82	14.58	
NJ	26	99.42	15.10	

***$p \leq .001$

[a]SJ - Prefers to works with facts and likes a planned, decided, orderly life style.

SP - Prefers to work with facts and likes a flexible, spontaneous life style.

NP - Prefers to look for possibilities, relationships and inferred meanings of experiences and likes a flexible, spontaneous life style.

NJ - Prefers to look for possibilities, relationships and inferred meanings of experiences and likes a planned, decided, orderly life style.

TABLE 22

PAIRWISE COMPARISONS OF THE MEAN INTELLIGENCE SCORES OF THE SENSING AND INTUITIVE MBTI PERSONALITY TYPES WITH JUDGING AND PERCEIVING USING THE NEWMAN KEULS PROCEDURE

SNJP[a]

Group	Mean	Differences			
NP	108.82	0.0			
NJ	99.42	9.39**	0.0		
SP	98.35	10.47**	1.08	0.0	
SJ	94.08	14.47**	5.34	4.26	0.0
		108.82	99.42	98.35	94.08
		NP	NJ	SP	SJ
r =		4	3	2	
r (.05)		3.63	3.31	2.77	
r (.01)		4.40	4.12	3.64	
q = 1.70					
q (.05)*		6.17	5.63	4.71	
q (.01)**		7.48	7.00	6.19	

*p ≤ .05

**p ≤ .01

[a]SJ - Prefers to work with facts and likes a planned, decided, orderly life style.

SP - Prefers to work with facts and likes a flexible, spontaneous life style.

NP - Prefers to look for possibilities, relationships and inferred meanings of experiences and likes a flexible, spontaneous life style.

NJ - Prefers to look for possibilities, relationships and inferred meanings of experiences and likes a planned, decided, orderly life style.

Because of the significant differences in mean intelligence scores between the sensing and intuitive students and between the judging and perceptive students, Hypothesis 2 is rejected.

Hypothesis 3: There is no statistically significant difference between mean intelligence scores of students classified according to their cognitive preference orientation.

The analysis of variance was used to determine if any significant differences existed between the mean intelligence scores of students classified according to cognitive preference orientation (M, A, and Q). The results of this analysis is presented in Table 23. The F-ratio of 3.37 is not significant. Thus, there is no significant difference between the mean intelligence scores of the subjects when classified according to cognitive preference orientation (M, A, and Q). The observed differences could be explained by chance alone.

The analysis of variance was again used to determine if any significant differences existed between the mean intelligence scores of students classified according to cognitive preference orientation (MA, MQ, and AQ). The F-ratio of 2.18 obtained from this analysis (see Table 24) was not significant. Any differences observed between these mean intelligence scores could have

TABLE 23

ANALYSIS OF VARIANCE OF THE MEAN INTELLIGENCE SCORES OF STUDENTS CLASSIFIED ACCORDING TO THEIR COGNITIVE PREFERENCE ORIENTATION M, A, Q[a]

Cognitive Preference Orientation	N	Mean	Standard Deviation	F-ratio
M	14	92.21	10.40	
A	34	103.18	15.04	3.37
Q	10	104.50	15.81	

[a] M - Accepts information for its own sake with no consideration for its implications, application or limitations.

A - Accepts scientific information in view of its practicability and applicability in a general, social and scientific context.

Q - Critical questioning or challenging of scientific information as to its completeness, general validity or limitations.

TABLE 24

ANALYSIS OF VARIANCE OF THE MEAN INTELLIGENCE SCORES OF STUDENTS CLASSIFIED ACCORDING TO THEIR COGNITIVE PREFERENCE ORIENTATION MA, MQ, AQ[a]

Cognitive Preference Orientation	N	Mean	Standard Deviation	F-ratio
MA	114	96.65	15.69	
MQ	59	99.49	13.32	2.18
AQ	62	101.54	15.18	

[a]M - Accepts information for its own sake with no consideration for its implications, application or limitations.

A - Accepts scientific information in view of its practicability and applicability in a general, social or scientific context.

Q - Critical questioning or challenging of scientific information as to its completeness, general validity or limitations.

occurred simply by chance and are not necessarily due to an individual's MA, MQ, or AQ cognitive preference orientation.

Since no statistically significant differences between the mean intelligence scores of students classified according to their cognitive preference orientation (M, A, Q, or MA, MQ, AQ) could be detected, Hypothesis 3 is not rejected.

Question 3

Do eighth-grade science students, classified according to their MBTI personality types, differ in their attitudes toward science and scientists?

Hypothesis 4: There is no statistically significant difference in attitudes toward science and scientists between the MBTI personality types.

The means and standard deviations of the scores for Part I (attitudes toward science) and Part II (attitudes toward scientists) of the SASAI are presented in Table 25. An analysis of variance was used to determine if there were any differences between these scores of the EI, SN, TF, and JP MBTI personality types. The results of these analyses are presented in the same table.

No significant differences between the means of

TABLE 25

ANALYSIS OF VARIANCE OF ATTITUDE SCORES OF PART I (ATTITUDES TOWARD SCIENCE) AND PART II (ATTITUDES TOWARD SCIENTISTS) OF THE SASAI FOR THE EI, SN, TF AND JP[a] MBTI PERSONALITY TYPES

Personality Types	N	Mean	Standard Deviation	F-ratio
Part I-Attitudes Toward Science				
E	149	14.93	2.54	0.29
I	115	14.76	2.49	
S	170	14.81	2.63	0.16
N	94	14.94	2.31	
T	89	14.88	2.70	0.01
F	175	14.84	2.43	
J	97	14.63	2.55	1.20
P	167	14.98	2.50	
Part II-Attitudes Toward Scientists				
E	149	20.88	4.50	0.15
I	115	20.65	4.93	
S	170	20.87	4.77	0.18
N	94	20.62	4.52	
T	89	20.90	4.84	0.09
F	175	20.72	4.60	
J	97	20.77	4.70	0.04
P	167	20.78	4.67	

[a] E - Relates more easily to the outer world of actions, objects and persons than to the inner world of concepts and ideas.

I - Relates more easily to the inner world of ideas and concepts than to the outer world of actions, objects and persons.

S - Would rather work with known facts than look for possibilities, relationships and inferred meanings of experiences.

N - Would rather look for possibilities, relationships and inferred meanings of experience than work with known facts.

T - Bases judgments more on impersonal analysis, logical order, and cause and effect than on personal importance and values.

F - Bases judgments more on personal importance and values than on impersonal analysis, logical order, and cause and effect.

J - Likes a planned, decided, orderly life style better than a flexible, spontaneous life style.

P - Likes a flexible, spontaneous life style better than a planned, decided, orderly life style.

the attitude scores were detected between any of the MBTI personality types. The F-ratios of 0.29 for EI, 0.16 for SN, 0.01 for TF, and 1.20 for JP for Part I (attitudes toward science) scores of the SASAI are not significant. Likewise, the F-ratios of 0.15 for EI, 0.18 for SN, 0.09 for TF and 0.04 for JP for Part II (attitudes toward scientists) scores of the SASAI are not significant. Therefore, Hypothesis 4 is not rejected.

The analysis of the data indicates that there are no significant differences between extraverts (E) and introverts (I), between sensing (S) and intuitive (N) students, between thinking (T) and feeling (F) students, and between judging (J) and perceiving (P) students when attitudes about science and scientists are considered. The major MBTI personality types do not have widely differing views of science and scientists.

Question 4

Is there any relationship between the attitudes toward science and scientists of eighth-grade students and their intelligence?

Hypothesis 5: There is no statistically significant relationship between intelligence and attitudes toward science and scientists.

A correlation statistical analysis was used to analyze this hypothesis. The correlation coefficient indicates that degree of relationship between two variables, i.e., to what extent changes in one variable go with changes in the other variable. Both variables are observed in situ without being fixed at predetermined levels. The relationship between two given variables does not necessarily imply that one variable is the cause of the other variable. Oftentimes, it is found that a relationship exists between two variables because they are related to, or caused by, a third variable.

Using the correlation statistical analysis, a significant correlation was found between the scores of Part I (attitudes toward science) but not between the scores of Part II (attitudes toward scientists) of the SASAI and the intelligence scores of the students in this study. As seen in Table 26, the Pearson product-moment correlation coefficient of 0.21 for Part I (attitudes toward science) scores of the SASAI and the derived intelligence scores is significant. The Pearson product-moment correlation coefficient of 0.09 for Part II (attitudes toward scientists) scores of the SASAI and the derived intelligence scores is not significant.

Although the statistically significant correlation coefficient of 0.21 is low, it does suggest a relationship

TABLE 26

CORRELATION OF PART I (ATTITUDES TOWARD SCIENCE) AND PART II (ATTITUDES TOWARD SCIENTISTS) SCORES OF THE SASAI AND INTELLIGENCE SCORES

Variables	Correlation Coefficient
Part I Scores and Intelligence Scores	0.21***
Part II Scores and Intelligence Scores	0.09

***$p \leq .001$

such that the higher the intelligence score, the higher a student scored on Part I (attitudes toward science) of the SASAI. However, this relationship must be interpreted with some caution in terms of educational significance. Since this relationship is statistically significant, Hypothesis 5 is rejected.

Question 5

Do eighth-grade science students, classified according to their MBTI personality types and cognitive preference orientation, differ in science achievement?

Hypothesis 6: There is no statistically significant difference in mean science achievement scores between the MBTI personality types.

The analysis of variance was used to analyze the differences between mean science achievement scores of the MBTI personality types. In addition, in order to fully explore these differences, the analysis of covariance (ANCOVA) was used. Barron (1974) has succinctly described this statistical procedure. She states:

> A method for testing the significance of differences among means which have been influenced by one or more uncontrolled variables is called the analysis of covariance. [Covariance] ... adjusts the means for the effect of the uncontrolled variable and

> makes the necessary modifications in sampling error. The corrected sampling error is then used to test for the significance of differences among the adjusted means. The adjustments made in the analysis are based on the application of regression analysis to the data. The result is that the groups are made comparable with respect to the uncontrolled variable.
>
> Covariance tests for a difference in the means of the residuals. The residuals are the differences between the actual observations and a regression quantity based on the associated second variable. [Covariance] ... provides tests of significance for the comparison groups whose members may have been stratified and whose members have been measured with regard to one or more variable characteristics other than the criterion.
>
> (Barron, 1974, pp. 41-42)

It was anticipated that any differences between science achievement scores of the MBTI personality types would be detected by the analysis of variance. However, the analysis of covariance was also used to statistically remove the effects of intelligence, i.e., intelligence scores were used as covariates.

The individual science scores of the students ranged from 1.0 to 20.0 with a mean of 14.1. The mean science achievement scores of the sixteen individual MBTI personality types are presented in Table 27.

EI, SN, TF, and JP MBTI Personality Types. The results of the analyses of variance and covariance of the mean science achievement scores for the EI, SN, FT, and JP MBTI personality types are presented in Table 28.

TABLE 27

MEAN SCIENCE ACHIEVEMENT SCORES OF THE SIXTEEN INDIVIDUAL MBTI PERSONALITY TYPES

	SENSING TYPES with THINKING	SENSING TYPES with FEELING	INTUITIVE TYPES with FEELING	INTUITIVE TYPES with THINKING	
	ISTJ	*ISFJ*	*INFJ*	*INTJ*	JUDGING
	N = 12 % = 4.55	N = 20 % = 7.58	N = 11 % = 4.17	N = 4 % = 1.52	
Mean	12.33	12.20	12.73	17.25	
SD	3.63	4.76	3.85	0.50	
	ISTP	*ISFP*	*INFP*	*INTP*	PERCEPTIVE
	N = 14 % = 5.30	N = 24 % = 9.09	N = 19 % = 7.20	N = 11 % = 4.17	
Mean	13.71	14.83	16.16	15.55	
SD	3.60	2.79	2.41	4.37	
	ESTP	*ESFP*	*ENFP*	*ENTP*	PERCEPTIVE
	N = 16 % = 6.06	N = 44 % = 16.67	N = 29 % = 10.98	N = 10 % = 3.79	
Mean	15.31	14.07	14.14	15.60	
SD	2.80	3.43	4.50	1.84	
	ESTJ	*ESFJ*	*ENFJ*	*ENTJ*	JUDGING
	N = 19 % = 7.20	N = 21 % = 7.95	N = 7 % = 2.65	N = 3 % = 1.14	
Mean	12.00	13.43	15.00	14.67	
SD	4.78	3.93	2.00	2.08	

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TABLE 28

ANALYSIS OF VARIANCE AND COVARIANCE OF THE MEAN SCIENCE ACHIEVEMENT SCORES AND ADJUSTED MEANS FOR THE EI, SN, TF AND JP[a] MBTI PERSONALITY TYPES

Science Scores	Personality Types		F-ratio
	E	I	
Mean	14.07	14.15	0.02
Standard Deviation	3.79	3.81	
Adjusted Mean	14.00	14.22	0.34
	S	N	
Mean	13.61	15.00	8.34***
Standard Deviation	3.82	3.58	
Adjusted Mean	14.06	14.20	0.10
	T	F	
Mean	14.08	14.12	0.007
Standard Deviation	3.85	3.77	
Adjusted Mean	13.95	14.19	0.32
	J	P	
Mean	13.02	14.74	13.15***
Standard Deviation	4.14	3.43	
Adjusted Mean	13.57	14.42	3.86

***$p \leq .001$

[a]E - Relates more easily to the outer world of actions, objects and persons than to the inner world of concepts and ideas.

I - Relates more easily to the inner world of ideas and concepts than to the outer world of actions, objects and persons.

S - Would rather work with known facts than look for possibilities, relationships and inferred meanings.

N - Would rather work with known facts than look for possibilities, relationships and inferred meanings.

T - Bases judgments more on impersonal analysis, logical order, and cause and effect than on personal importance and values.

F - Bases judgments more on personal importance and values than on impersonal analysis, logical order, and cause and effect.

J - Likes a planned, decided, orderly life style better than a flexible, spontaneous life style.

P - Likes a flexible, spontaneous life style better than a planned, decided, orderly life style.

EI. The F-ratio of 0.02 obtained by the analysis of variance was not significant. Likewise, the F-ratio of 0.34 obtained by the analysis of covariance was not significant. These analyses suggest that there is no significant difference in mean science achievement scores between extraverts (E) and introverts (I).

SN. Although the F-ratio of 8.34 resulting from the analysis of variance was significant, the F-ratio of 0.10 resulting from the analysis of covariance was not significant. Thus, there is no significant difference in mean science achievement scores between sensing (S) and intuitive (N) students other than what would be expected by chance. Differences in science achievement appear to be related to intelligence rather than to a sensing or intuitive preference.

TF. The F-ratios of 0.007 resulting from the analysis of variance and 0.32 resulting from the analysis of covariance were not significant. These extremely low F-ratios suggest rather strongly that there is no significant difference between mean science achievement scores of the thinking (T) and feeling (F) students.

JP. The F-ratio of 13.15 resulting from the analysis of variance was significant. However, the F-ratio of 2.86 resulting from the analysis of covariance was not significant. Thus, when the effects of

intelligence were statistically removed by the analysis of covariance, perceptive (P) students performed as well as judging (J) students on the Science Knowledge Test.

SNTF, EISN, and SNJP MBTI Personality Type Groups. The results of the analyses of variance and covariance for the SNTF and EISN MBTI personality type groups are presented in Tables 29 and 30. The F-ratios of 3.45 for the SNTF and 3.01 for the EISN MBTI personality type groups, obtained from the analysis of variance, are not significant. Likewise, the F-ratios of 0.28 for the SNTF and 0.16 for the EISN MBTI personality type groups, obtained from the analysis of covariance, are not significant. These analyses indicate that there is no significant difference in science achievement between the SNTF or between the EISN MBTI personality type groups.

The F-ratio of 6.91 for the SNJP MBTI personality type groups, obtained from the analysis of variance, was significant. However, the F-ratio of 2.60 obtained from the analysis of covariance was not significant (see Table 31). These analyses indicate that there is no significant difference in science achievement between the SNJP MBTI personality type groups. Any differences could be explained by intelligence rather than by MBTI personality types.

TABLE 29

ANALYSIS OF VARIANCE AND COVARIANCE OF THE MEAN SCIENCE ACHIEVEMENT SCORES AND ADJUSTED MEANS OF THE SENSING AND INTUITIVE MBTI PERSONALITY TYPES WITH THINKING AND FEELING SNTF[a]

Science Scores	Personality Type Group ST	SF	NF	NT	F-ratio
Mean	13.33	13.77	14.31	15.71	3.45
S.D.	3.99	3.79	3.78	3.00	
Adj. Mean	13.77	14.21	14.15	14.33	0.28

[a]ST - "Practical and matter-of-fact": Prefer to work with known facts and make judgments based on impersonal analysis, logical order, and cause and effect.

SF - "Sympathetic and friendly": Prefer to work with known facts and make judgments based on personal importance values.

NF - "Enthusiastic and insightful": Prefer to look for possibilities, relationships and inferred meanings of experiences and make judgments based on personal importance and values.

NT - "Logical and ingeneous": Prefer to look for possibilities, relationships and inferred meanings of experiences and make judgments based on impersonal analysis, logical order, and cause and effect.

TABLE 30

ANALYSIS OF VARIANCE AND COVARIANCE OF THE MEAN SCIENCE ACHIEVEMENT SCORES AND ADJUSTED MEANS OF THE EXTRAVERT AND INTROVERT MBTI PERSONALITY TYPES WITH SENSING AND INTUITION EISN[a]

Science Scores	Personality Type Group SJ	SP	NP	NJ	F-ratio
Mean	15.27	14.76	13.43	13.74	3.01
S.D.	3.53	3.65	3.84	3.83	
Adj. Mean	14.39	14.02	14.14	13.96	0.16

[a]IN - Relates easily to the inner world of ideas and concepts and prefers to look for possibilities, relationships and inferred meanings of experiences.

EN - Relates easily to the outer world of actions, objects and persons and prefers to look for possibilities, relationships and inferred meanings of experiences.

IS - Relates easily to the inner world of ideas and concepts and prefers to work with known facts.

ES - Relates easily to the outer world of actions, objects and persons and prefers to work with known facts.

TABLE 31

ANALYSIS OF VARIANCE AND COVARIANCE OF THE MEAN SCIENCE ACHIEVEMENT SCORES AND ADJUSTED MEANS OF THE SENSING AND INTUITIVE MBTI PERSONALITY TYPES WITH JUDGING AND PERCEIVING SNJP[a]

Science Scores	Personality Type Group SJ	SP	NP	NJ	F-ratio
Mean	12.53	14.41	15.25	14.32	6.91***
S.D.	4.32	3.21	3.70	3.21	
Adj. Mean	13.24	14.64	14.14	14.43	2.60

***$p \leq .001$

[a]SJ - Prefers to work with facts and likes a planned, decided orderly life style.

SP - Prefers to work with facts and likes a flexible, spontaneous life style.

NP - Prefers to look for possibilities, relationships and inferred meanings of experiences and likes a flexible, spontaneous life style.

NJ - Prefers to look for possibilities, relationships and inferred meanings of experiences and likes a planned, decided, orderly life style.

The previous analyses suggest that science achievement is related to intelligence rather than to an individual's MBTI personality type preference. Because no statistically significant differences between the mean science achievement scores of the MBTI personality types or type groups could be detected, Hypothesis 6 is not rejected.

Hypothesis 7: There is no statistically significant difference in mean achievement scores between students classified according to their cognitive preference orientation.

An analysis of variance was used to determine if any significant differences existed between the mean science achievement scores of students classified according to their cognitive preference orientation. As seen in Table 32, the F-ratio of 1.69 was not significant. Likewise, the F-ratio of 0.84 was not significant.

Any differences observed between the science scores could have occurred simply by chance and are not necessarily due to an individual's cognitive preference orientation. Therefore, Hypothesis 7 is not rejected.

TABLE 32

ANALYSIS OF VARIANCE OF THE MEAN SCIENCE ACHIEVEMENT SCORES OF STUDENTS CLASSIFIED ACCORDING TO THEIR COGNITIVE PREFERENCE ORIENTATION M, A, Q, MA, MQ, AQ[a]

Cognitive Preference Orientation	N	Mean	Standard Deviation	F-ratio
M	14	13.50	3.01	
A	34	15.53	2.86	1.69
Q	10	14.90	3.22	
MA	112	14.16	3.80	
MQ	58	14.12	3.71	0.84
AQ	60	13.42	3.71	

[a] M - Accepts information for its own sake with no consideration for its implication, application or limitations.

A - Accepts scientific information in view of its practicability and applicability in a general, social or scientific context.

Q - Critical questioning or challenging of scientific information as to its completeness, general validity or limitations.

Question 6

Is there any relationship between the science achievement of eighth-grade science students and their attitudes toward science and scientists?

Hypothesis 8: There is no statistically significant relationship between achievement scores in science and attitudes toward science and scientists.

Using a correlation statistical analysis, a significant correlation was found between the scores of Part I (attitudes toward science) of the SASAI and science achievement scores. Likewise, a significant correlation was found between the scores of Part II (attitudes toward scientists) of the SASAI and science achievement scores. As seen in Table 33, the Pearson product-moment correlations of 0.33 and 0.23 are significant.

Although both correlation coefficients are statistically significant, they are nevertheless low. The scatterplot is a visual representation of correlation. Each point on a scatterplot represents a pair of scores for one individual. The scatterplots seen in Tables 34 and 35 indicate that the relationships are low. However, the scatterplots indicate a general trend such that students with higher science achievement scores tend to have a more positive attitude toward science and scientists.

TABLE 33

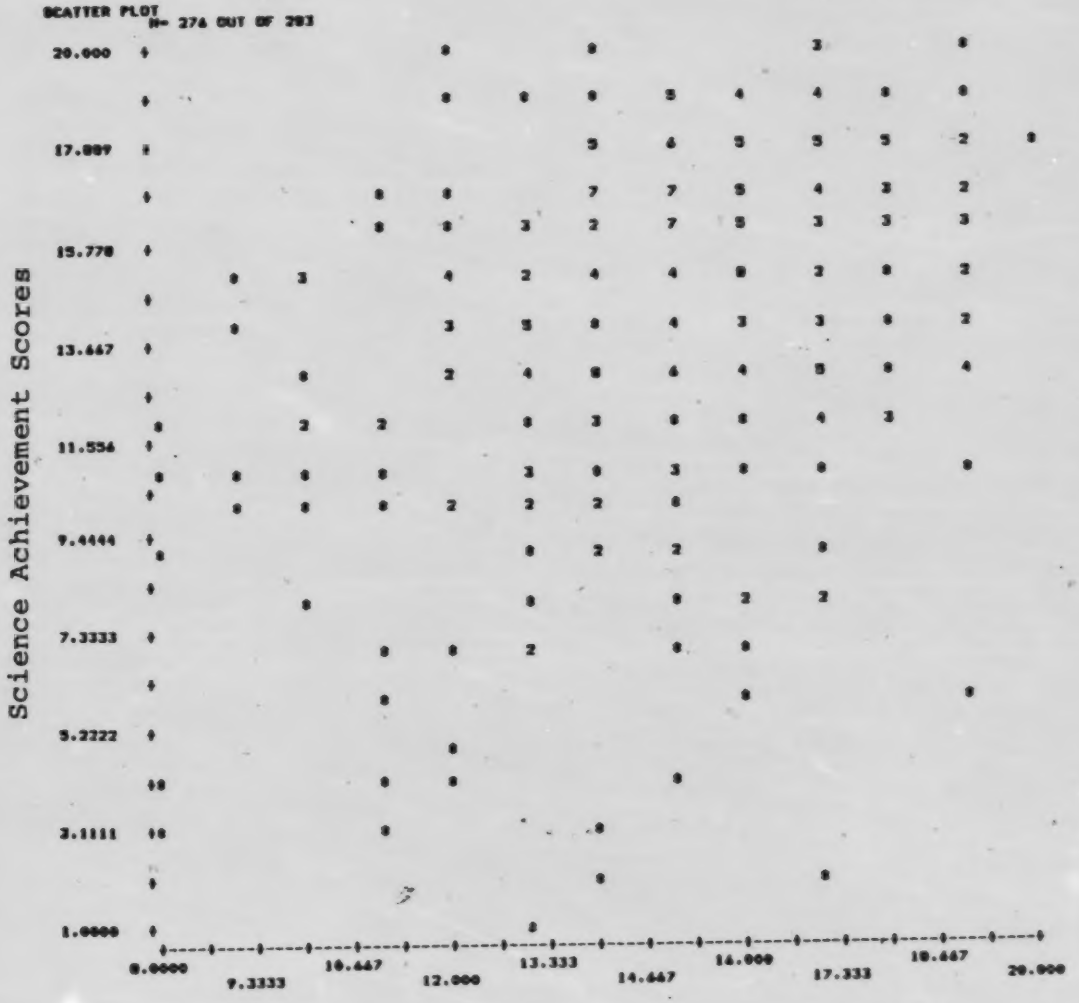
CORRELATION OF PART I (ATTITUDES TOWARD SCIENCE) AND PART II (ATTITUDES TOWARD SCIENTISTS) SCORES OF THE SASAI AND SCIENCE ACHIVEMENT SCORES

Variables	Correlation Coefficient
Part I Scores and Science Achievement Scores	0.33***
Part II Scores and Science Achievement Scores	0.23***

***$p \leq .001$

TABLE 34

SCATTERPLOT OF THE RELATIONSHIP BETWEEN SCIENCE ACHIEVEMENT SCORES AND SCORES OF PART I (ATTITUDES TOWARD SCIENCE) OF THE SASAI

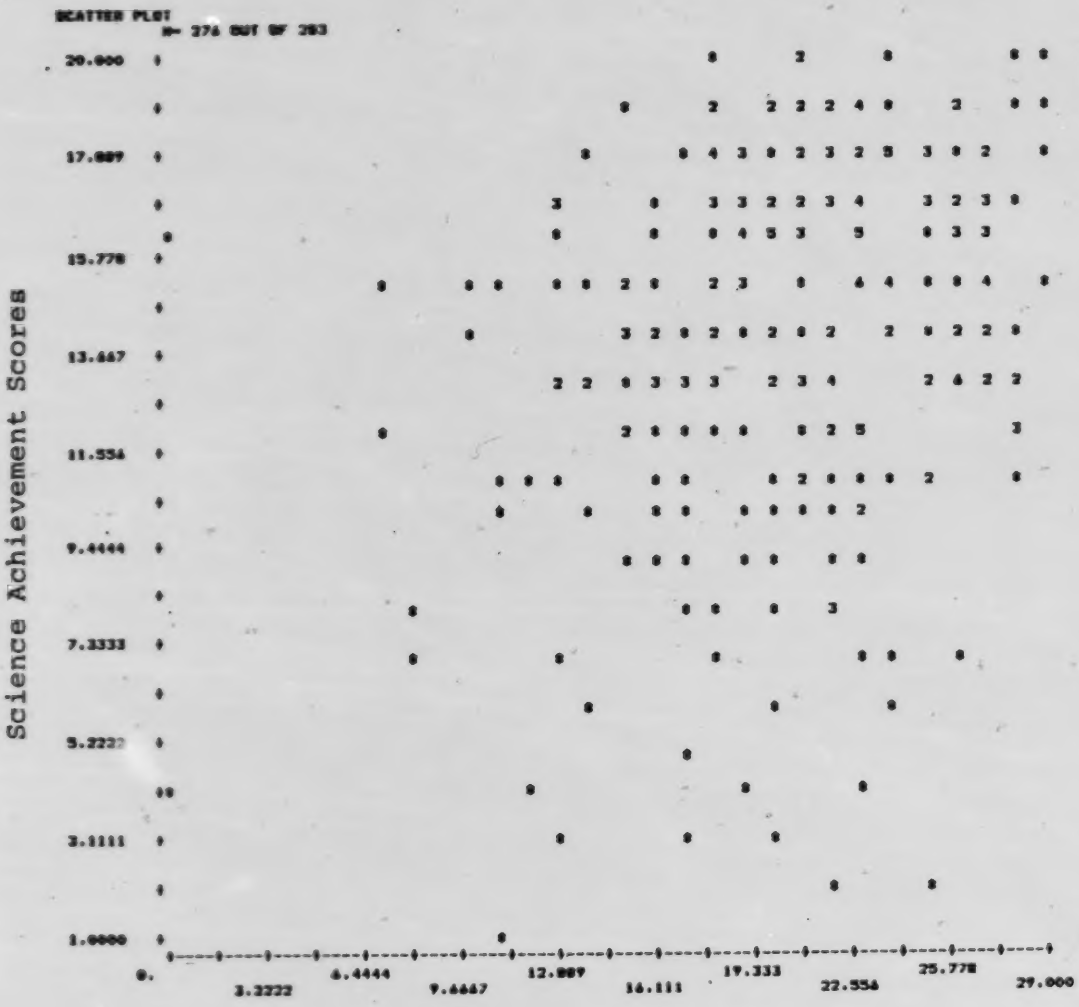


* = one pair of scores at a given point.

number = the number of pairs of scores at a given point.

TABLE 35

SCATTERPLOT OF THE RELATIONSHIP BETWEEN SCIENCE ACHIEVEMENT SCORES AND SCORES OF PART II (ATTITUDES TOWARD SCIENTISTS) OF THE SASAI



* = one pair scores at a given point.
number = the number of pairs of scores at a given point.

Because of the statistically significant relationships between science achievement scores and attitudes toward science and scientists, Hypothesis 8 is rejected.

Question 7

Is there any relationship between the sex of eighth-grade science students classified according to their MBTI personality types; cognitive preference orientation; or attitudes toward science and scientists?

Hypothesis 9: There is no statistically significant relationship between the MBTI personality types and sex of students.

EI, SN, TF, and JP MBTI Personality Types. The results of these analyses are presented in Table 36. The chi-square values of 9.55 for EI, 1.02 for SN, 3.66 for TF, and 0.27 for JP MBTI personality types are not significant.

SNTF, EISN, and SNJP MBTI Personality Type Groups. The results of these analyses are presented in Tables 37-39. The chi-square values of 4.70 for SNTF, 13.21 for EISN, and 1.64 for SNJP MBTI personality type groups are not significant.

These analyses indicate that there is no significant relationship between sex of students and MBTI personality types or type groups. Therefore Hypothesis 9 is not rejected.

TABLE 36

ANALYSIS OF MBTI PERSONALITY TYPES EI, SN, TF AND JP[a] ACCORDING TO SEX

Personality Types	Sex Observed Frequencies Male	(%)	Female	(%)	Total	(%)
E	71	(48.0)	82	(66.7)	153	(56.5)
I	77	(52.0)	41	(33.3)	118	(43.5)
Total	148	(54.6)	123	(45.4)	271	(100.0)
$\chi^2 = 9.55$	cc = 0.18					
S	99	(66.9)	75	(61.0)	174	(64.2)
N	49	(33.1)	48	(39.0)	97	(35.8)
Total	148	(54.6)	123	(45.4)	271	(100.0)
$\chi^2 = 1.02$	cc = 0.06					
T	57	(38.5)	34	(27.6)	91	(33.6)
F	91	(61.5)	89	(72.4)	180	(66.4)
Total	148	(54.6)	123	(45.4)	271	(100.0)
$\chi^2 = 3.66$	cc = 0.12					
J	52	(35.1)	47	(38.2)	99	(36.5)
P	96	(64.9)	76	(61.8)	172	(63.5)
Total	148	(54.6)	123	(45.4)	271	(100.0)
$\chi^2 = 0.27$	cc = 0.03					

[a] E - Relates more easily to the outer world of actions, objects and persons than to the inner world of concepts and ideas.

I - Relates more easily to the inner world of concepts and ideas than to the outer world of actions, objects and persons.

S - Would rather work with known facts than look for possibilities, relationships and inferred meanings.

N - Would rather look for possibilities, relationships and inferred meanings than work with known facts.

T - Bases judgments more on impersonal analysis, logical order, and cause and effect than on personal importance and values.

F - Bases judgments more on personal importance and values than on impersonal analysis, logical order, and cause and effect.

J - Likes a planned, decided, orderly life style better than a flexible, spontaneous life style.

P - Likes a flexible, spontaneous life style better than a planned, decided, orderly life style.

TABLE 37

ANALYSIS OF THE SENSING AND INTUITIVE MBTI PERSONALITY TYPES WITH THINKING AND FEELING ACCORDING TO SEX
SNTF[a]

Personality Type Group	Sex Observed Frequencies Male	(%)	Female	(%)	Total	(%)
ST	41	(27.7)	21	(17.1)	62	(22.9)
SF	58	(39.2)	54	(43.9)	112	(41.3)
NF	33	(22.3)	35	(28.5)	68	(25.1)
NT	16	(10.8)	13	(10.6)	29	(10.7)
Total	148	(54.6)	123	(45.4)	271	(100.0)

$\chi^2 = 4.70$ cc = 0.13

[a]ST - "Practical and matter-of-fact": Prefer to work with known facts and make judgments based on impersonal analysis, logical order, and cause and effect.

SF - "Sympathetic and friendly": Prefer to work with known facts and make judgments based on personal importance and values.

NP - "Enthusiastic and insightful": Prefer to look for possibilities, relationships and inferred meanings of experiences and make judgments based on personal importance and values.

NT - "Logical and ingeneous": Prefer to look for possibilities, relationships and inferred meanings of experiences and make judgments based on impersonal analysis, logical order, and cause and effect.

TABLE 38

ANALYSIS OF THE EXTRAVERT AND INTROVERT MBTI PERSONALITY TYPES WITH SENSING AND INTUITION ACCORDING TO SEX EISN[a]

Personality Types	Sex Observed Frequencies Male	(%)	Female	(%)	Total	(%)
IN	25	(16.9)	20	(16.3)	45	(16.6)
EN	24	(16.2)	28	(22.8)	52	(19.2)
IS	52	(35.1)	21	(17.1)	73	(26.9)
ES	47	(31.8)	54	(43.9)	101	(37.3)
Total	148	(54.6)	123	(45.4)	271	(100.0)

$\chi^2 = 12.31$ cc = 0.21

[a]IN - Relates easily to the inner world of ideas and concepts and prefers to look for possibilities, relationships and inferred meanings of experiences.

EN - Relates easily to the outer world of actions, objects and persons and prefers to look for possibilities, relationships and inferred meanings of experiences.

IS - Relates easily to the inner world of ideas and concepts and prefers to work with known facts.

ES - Relates easily to the outer world of actions, objects and persons and prefers to work with known facts.

TABLE 39

ANALYSIS OF THE SENSING AND INTUITIVE MBTI PERSONALITY TYPES WITH JUDGING AND PERCEIVING ACCORDING TO SEX SNJP[a]

Personality Type	Sex Observed Frequencies Male	(%)	Female	(%)	Total	(%)
SJ	39	(26.4)	34	(27.6)	73	(26.9)
SP	60	(40.5)	41	(33.3)	101	(37.3)
NP	36	(24.3)	35	(18.5)	71	(26.2)
NJ	13	(8.8)	13	(10.6)	26	(9.6)
Total	148	(54.6)	123	(45.4)	271	(100.0)

$\chi^2 = 1.64$ cc = 0.08

[a]SJ - Prefers to work with facts and likes a planned, decided, orderly life style.

SP - Prefers to work with facts and likes a flexible, spontaneous life style.

NP - Prefers to look for possibilities, relatoinships and inferred meanings of experiences and likes a flexible, spontaneous life style.

NJ - Prefers to look for possibilities, relationships and inferred meanings of experiences and likes a planned, decided, orderly life style.

However, the general trend reported in the literature is that males prefer thinking to feeling and that females prefer feeling to thinking. The result of the TF analysis indicates that males and females do not differ in their preference for thinking and feeling. This may be indicative of a trend suggested by McCaulley (1976b), a shift from the "thinking male" to the "feeling male." McCaulley (1976b) suspects that the shift (in females as well as males) may reflect a general shift toward humanistic values in today's society.

Hypothesis 10: There is no statistically significant relationship between the cognitive preference orientation and sex of students.

The chi-square values of 0.36 and 0.32 indicated in Table 40 are obviously not significant. The sex of a student is therefore independent of cognitive preference orientation. Males and females do not have significantly differing preferences for the memory of facts (M), the application of information (A), or the questioning of information (Q). Any observed differences are due to chance. Therefore, Hypothesis 10 is not rejected.

TABLE 40

ANALYSIS OF MALES AND FEMALES ACCORDING TO THEIR COGNITIVE PREFERENCE ORIENTATION M, A, Q AND MA, MQ, AQ[a]

Cognitive Preference	Sex Observed Frequencies Male	(%)	Female	(%)	Total	(%)
M	7	(21.2)	7	(28.0)	14	(24.1)
A	20	(58.8)	14	(41.2)	34	(58.6)
Q	6	(18.2)	4	(16.0)	10	(17.3)
Total	33	(56.9)	25	(43.1)	58	(100.0)
$\chi^2 = 0.36$	cc = 0.08					
MA	59	(46.8)	55	(50.5)	114	(48.5)
MQ	33	(26.2)	26	(23.9)	59	(25.1)
AQ	34	(27.0)	28	(25.7)	62	(26.4)
Total	126	(53.6)	109	(46.4)	235	(100.0)
$\chi^2 = 0.32$	cc = 0.04					

[a] M - Accepts information for its own sake with no consideration for its implications, application or limitations.

A - Accepts scientific information in view of its practicability and applicability in a general, social or scientific context.

Q - Critical questioning or challenging of scientific information as to its completeness, general validity or limitations.

Hypothesis 11: There is no statistically significant difference in attitudes toward science and scientists between males and females.

A visual inspection of the means of the attitude scores of Part I (attitudes toward science) and Part II (attitudes toward scientists) of the SASAI for males and females indicated miniscule differences (see Table 41). The F-ratios of 0.34 for Part I (attitudes toward science) scores and 0.007 for Part II (attitudes toward scientists) scores obtained by analyses of variance are not significant.

These analyses indicate that there is no significant difference between males and females when attitudinal responses about science and scientists are considered. It is valid to say, since Hypothesis 11 is not rejected, that males and females do not have significantly differing views of science and scientists.

Question 8

Is there any relationship between the geographic area (urban, suburban and rural) of eighth-grade science students, and their MBTI personality types; cognitive preference orientation; and attitudes toward science and scientists?

TABLE 41

ANALYSIS OF VARIANCE OF THE PART I (ATTITUDES TOWARD SCIENCE) AND PART II (ATTITUDES TOWARD SCIENTISTS) SCORES OF THE SASAI FOR MALES AND FEMALES IN THE TOTAL SAMPLE

	Sex	N	Mean	Standard Deviation	F-ratio
Part I-Attitudes Toward Science	M	147	14.95	2.39	0.34
	F	129	14.77	2.68	
Part II-Attitudes Toward Scientists	M	147	20.64	5.05	0.007
	F	129	20.59	4.85	

Hypothesis 12: There is no statistically significant relationship between MBTI personality types and geographic area.

According to the chi-square values seen in Table 42 of 5.61 for EI, 0.81 for SN, 2.96 for TF, and 4.75 for JP, which are not significant, these MBTI personality types occur with similar frequencies in urban, suburban, and rural geographic areas. Likewise, the SNTF, EISN, and SNJP MBTI personality type groups occur with similar frequencies among students in urban, suburban, and rural geographic areas as evidence by the insignificant chi-square values of 8.45 (Table 43) for SNIF, 13.28 (Table 44) for EISN, and 7.46 (Table 45) for SNJP MBTI personality type groups respectively. Therefore, Hypothesis 12 is not rejected.

Hypothesis 13: There is no statistically significant relationship between cognitive preference orientation and geographic area.

The chi-square values of 5.55 and 1.77 reported in Table 46 are not significant. Therefore, Hypothesis 13 is not rejected. Students in urban, suburban, and rural geographic areas do not differ in their cognitive preference orientation.

TABLE 42

ANALYSIS OF MBTI PERSONALITY TYPES EI, SN, TF AND JP[a] ACCORDING TO GEOGRAPHIC AREA

Personality Types	Geographic Area[b] Observed Frequencies U	(%)	S	(%)	R	(%)	Total	(%)
E	34	(48.6)	36	(50.7)	83	(63.8)	153	(56.5)
I	36	(51.4)	35	(49.3)	47	(36.2)	118	(43.5)
Total	70	(25.9)	71	(26.2)	130	(47.9)	271	(100.0)
$\chi^2 = 4.75$	cc = 0.13							
S	48	(68.6)	44	(62.0)	82	(63.1)	174	(64.2)
N	22	(31.4)	27	(28.0)	48	(36.9)	97	(35.8)
Total	70	(25.9)	71	(26.2)	130	(47.9)	271	(100.0)
$\chi^2 = 0.81$	cc = 0.05							
T	29	(41.4)	20	(28.2)	42	(32.3)	91	(33.6)
F	41	(58.6)	51	(71.8)	88	(67.7)	180	(66.4)
Total	70	(25.9)	71	(26.2)	130	(47.9)	271	(100.0)
$\chi^2 = 2.96$	cc = 0.10							
J	33	(47.1)	22	(31.0)	44	(33.8)	99	(36.5)
P	37	(52.9)	49	(69.0)	86	(66.2)	172	(63.5)
Total	70	(25.9)	71	(26.2)	130	(47.9)	271	(100.0)
$\chi^2 = 4.75$	cc = 0.13							

[a]E - Relates more easily to the outer world of actions, objects and persons than to the inner world of concepts and ideas.

I - Relates more easily to the inner world of concepts and ideas than to the outer world of actions, objects and persons.

S - Would rather work with known facts than look for possibilities, relationships and inferred meanings.

N - Would rather look for possibilities, relationships and inferred meanings than work with known facts.

T - Bases judgments more on impersonal analysis, logical order, and cause and effect than on personal importance and values.

F - Bases judgments more on personal importance and values than on impersonal analysis, logical order, and cause and effect.

J - Likes a planned, decided, orderly life style better than a flexible, spontaneous life style.

P - Likes a flexible, spontaneous life style better than a planned, decided, orderly life style.

[b]U - Urban

S - Suburban

R - Rural

TABLE 43

ANALYSIS OF THE SENSING AND INTUITIVE MBTI PERSONALITY TYPES WITH THINKING AND FEELING ACCORDING TO GEOGRAPHIC AREA

SNTF[a]

Personality Types	Geographic Area[b] Observed Frequencies U	(%)	S	(%)	R	(%)	Total	(%)
ST	24	(34.3)	11	(15.5)	27	(20.8)	62	(22.9)
SF	24	(34.3)	33	(46.5)	55	(42.3)	112	(41.3)
NF	17	(24.3)	18	(25.4)	33	(25.4)	68	(25.1)
NT	5	(7.1)	9	(12.7)	15	(11.5)	29	(10.7)
Total	70	(15.9)	71	(26.2)	130	(47.9)	271	(100.0)

$\chi^2 = 8.45$ cc = 0.17

[a]ST - "Practical and matter-of-fact": Prefer to work with known facts and make judgments based on impersonal analysis, logical order, and cause and effect.

SF - "Sympathetic and friendly": Prefer to work with known facts and make judgments based on personal importance and values.

NP - "Enthusiastic and insightful": Prefer to look for possibilities, relationships and inferred meanings of experiences and make judgments based on personal importance and values.

NT - "Logical and ingeneous": Prefer to look for possibilities, relationships and inferred meanings of experiences and make judgments based on impersonal analysis, logical order, and cause and effect.

[b]U - Urban

S - Suburban

R - Rural

TABLE 44

ANALYSIS OF THE EXTRAVERT AND INTUITIVE MBTI PERSONALITY TYPES WITH SENSING AND INTUITION ACCORDING TO GEOGRAPHIC AREA

EISN[a]

Personality Types	Geographic Area[b] Observed Frequencies U	(%)	S	(%)	R	(%)	Total	(%)
IN	16	(22.9)	15	(21.1)	14	(10.8)	45	(16.6)
EN	6	(8.6)	12	(16.9)	34	(26.2)	52	(19.2)
IS	20	(28.6)	20	(28.2)	33	(25.4)	73	(26.9)
ES	28	(40.0)	24	(33.8)	49	(37.7)	101	(37.3)
Total	70	(25.9)	71	(26.2)	130	(47.9)	271	(100.0)

$\chi^2 = 13.28$ cc = 0.22

[a] IN - Relates easily to the inner world of ideas and concepts and prefers to look for possibilities, relationships and inferred meanings of experiences.

EN - Relates easily to the outer world of actions, objects and persons and prefers to look for possibilities, relationships and inferred meanings of experiences.

IS - Relates easily to the inner world of ideas and concepts and prefers to work with known facts.

ES - Relates easily to the outer world of actions, objects and persons and prefers to work with known facts

[b] U - Urban

S - Suburban

R - Rural

TABLE 45

ANALYSIS OF THE SENSING AND INTUITIVE MBTI PERSONALITY TYPES WITH JUDGING AND PERCEIVING ACCORDING TO GEOGRAPHIC AREA

SNJP[a]

Personality Types	Geographic Area[b] Observed Frequencies U	(%)	S	(%)	R	(%)	Total	(%)
SJ	23	(32.9)	18	(25.4)	32	(24.6)	73	(26.9)
SP	25	(35.7)	26	(36.6)	50	(38.5)	101	(37.3)
NP	12	(17.1)	23	(32.4)	36	(27.7)	71	(26.2)
NJ	10	(14.3)	4	(5.6)	12	(9.1)	26	(9.6)
Total	70	(25.9)	71	(26.2)	130	(47.9)	271	(100.0)

$\chi^2 = 7.46$ cc - 0.16

[a]SJ - Prefers to work with facts and likes a planned, decided, orderly life style.

SP - Prefers to work with facts and likes a flexible, spontaneous life style.

NP - Prefers to look for possibilities, relationships and inferred meanings of experiences and likes a flexible, spontaneous life style.

NJ - Prefers to look for possibilities, relationships and inferred meanings of experiences and likes a planned, decided life style.

[b]U - Urban

S - Suburban

R - Rural

TABLE 46

ANALYSIS OF SUBJECTS IN URBAN, SUBURBAN AND RURAL GEOGRAPHIC AREAS CLASSIFIED ACCORDING TO THEIR COGNITIVE PREFERENCE ORIENTATION M, A, Q AND MA, MQ, AQ[a]

Cognitive Preference Orientation	Geographic Area[b] Observed Frequencies U	(%)	S	(%)	R	(%)	Total	(%)
M	5	(29.4)	2	(13.3)	7	(26.9)	14	(24.2)
A	7	(41.2)	12	(80.0)	15	(57.7)	34	(58.6)
Q	5	(29.4)	1	(6.7)	4	(15.4)	10	(17.2)
Total	17	(29.3)	15	(25.9)	26	(44.8)	58	(100.0)
$\chi^2 = 5.55$	cc = 0.30							
MA	34	(49.3)	27	(45.0)	53	(50.0)	114	(48.5)
MQ	15	(21.7)	15	(25.0)	29	(27.4)	59	(25.1)
AQ	20	(29.0)	18	(30.0)	24	(22.6)	62	(26.4)
Total	69	(29.4)	60	(25.5)	106	(45.1)	235	(100.0)
$\chi^2 = 1.77$	cc = 0.09							

[a] M - Accepts information for its own sake with no consideration for its implications, application or limitations.

A - Accepts scientific information in view of its practicability and applicability in a general, social or scientific context.

Q - Critical questioning or challenging of scientific information as to its completeness, general validity or limitations.

[b] U - Urban

S - Suburban

R - Rural

Hypothesis 14: There is no statistically significant difference in attitudes toward science and scientists between students from urban, suburban, and rural geographic areas.

The F-ratio of 1.11 for Part I (attitudes toward science) and 4.45 for Part II (attitudes toward scientists) of the SASAI obtained by the analysis of variance are not significant. This indicates that there is no significant difference between students in urban, suburban, and rural geographic areas when attitudinal responses about science and scientists are considered. Therefore, Hypothesis 14 is not rejected.

TABLE 47

ANALYSIS OF VARIANCE OF THE MEAN SCORES OF PARTS I (ATTITUDES TOWARD SCIENCE) AND II (ATTITUDES TOWARD SCIENTISTS) OF THE SASAI ACCORDING TO GEOGRAPHIC AREA

Area	N	Mean	Standard Deviation	F-ratio
Part I (Attitudes Toward Science)				
Urban	77	14.61	1.72	
Suburban	71	15.23	2.43	1.11
Rural	128	14.81	1.50	
Part II (Attitudes Toward Scientists)				
Urgan	77	19.31	5.81	
Suburban	71	20.59	5.08	4.45
Rural	128	21.41	4.12	

CHAPTER V

SUMMARY, CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

Summary

The purpose of this study was to determine relationships among the MBTI personality types, cognitive preference orientation, science achievement, intelligence, attitudes toward science and scientists, sex, and geographic area, of eighth-grade science students.

Data were collected during May 1979 from 283 eighth-grade science students in urban (middle), suburban (junior high) and rural (middle) schools. Four instruments were used to collect the data:

1. Myers-Briggs Type Indicator (MBTI)
2. Cognitive Preference Examination-II (CPE-II)
3. Science and Scientists Attitude Inventory (SASAI)
4. Science Knowledge Test (SKT)

MBTI Analysis

The MBTI results classified the students in this study into the following types:

E - Extravert (56.5%) I - Introvert (63.5%) 1:1

S - Sensing (64.2%) N - Intuitive (35.8%) 2:1

T - Thinking	(33.6%)	F - Feeling	(66.4%) 1:2
J - Judging	(36.5%)	P - Perceiving	(63.5%) 1:2

CPO Analysis

The CPO results classified 278 students in this study into the following groups based on a single detectable preference:

M - Memory	14	(5.0%)
A - Application	34	(12.3%)
Q - Questioning	10	(3.6%)
NP - No Detectable Preference	220	(79.1%)

When classified according to two detectable preferences, the students were grouped as follows:

MA - Memory/Application	112	(40.3%)
MQ - Memory/Questioning	58	(20.8%)
AQ - Application/Questioning	60	(21.6%)
NP - No Detectable Preference	48	(17.3%)

SASAI Analysis

Individual scores ranged from 8 to 20 on Part I (attitudes toward science) of the SASAI, with a mean score of 14.89. Individual scores ranged from 0 to 29 on Part II (attitudes toward scientists) of the SASAI, with a mean score of 20.44.

SKT Analysis

The individual scores of the students on the SKT ranged from 1 to 20, with a mean science achievement score of 14.10.

Intelligence Analysis

An intelligence score was derived for each student from vocabulary scores provided by the participating schools. The individually derived intelligence scores ranged from 65 to 137, with a mean derived intelligence score of 99.90. One hundred and sixty-six students were classified on the basis of "high" intelligence (mean derived high intelligence score - 110.01). One hundred and seventeen students were classified on the basis of "low" intelligence (mean derived low intelligence score = 85.56).

Data Analysis

Fourteen null hypotheses were formulated and tested at $\alpha = .001$ to answer the eight questions proposed in this study.

Question 1: Do eighth-grade science students, classified according to their MBTI personality types, differ in their cognitive preference orientation?

Hypothesis 1: There is no statistically significant relationship between MBTI personality types and cognitive preference orientation.

This hypothesis was not rejected. The seven chi-square values for the one preference classification (M, A, Q) and MBTI personality types and type groups were not significant (EI - 0.85, SN - 0.36, TF - 0.27, JP - 0.54, SNTF - 1.44, EISN - 2.10, and SNJP - 2.16). Likewise, the seven chi-square values for the two preference classification and MBTI personality types and type groups were not significant (EI - 2.56, SN - 3.05, TF - 0.49, JP - 0.40, SNTF - 4.51, EISN - 13.39, and SNJP - 4.73).

Question 2: Is there a difference in intelligence between eighth-grade science students classified according to their MBTI personality types and cognitive preference orientation?

Hypothesis 2: There is no statistically significant difference between mean intelligence scores of the MBTI personality types.

This hypothesis was rejected. The mean intelligence score of 106.50 for intuitive (N) students was significantly higher than the mean intelligence score of 95.56 for sensing (S) students. The mean intelligence score of 102.67 for perceiving (P) students was significantly higher than the mean intelligence score of 95.49 for judging (J) students. No significant differences were

found between the mean intelligence scores of thinking (T) and feeling (F) students or between the mean intelligence scores of extraverts (S) and introverts (I).

Significant differences were also found between mean intelligence scores of the MBTI type groups as follows:

1. SNTF - NT (111.00) > ST (96.90)
   NF (104.29) > ST (96.90)
   NF (111.00) > SF (96.37)
   NT (111.00) > NF (104.29)
2. EISN - IN (107.22) > IS (94.14)
   IN (107.22) > ES (98.31)
   EN (105.50) > IS (94.14)
   EN (105.50) > ES (98.31)
3. SNJP - NP (108.82) > SJ (94.08)
   NP (108.82) > SP (98.35)
   NP (108.82) > NJ (99.42)

Hypothesis 3: There is no statistically significant difference between mean intelligence scores of students classified according to their cognitive preference orientation.

This hypothesis was not rejected. The F-ratios of 3.37 for a one preference classification (M, A, Q) and 2.18 for a two preference classification (MA, MQ, AQ) were not significant.

Question 3: Do eighth-grade science students, classified according to their MBTI personality types, differ in their attitudes toward science and scientists?

Hypothesis 4: There is no statistically significant difference in attitudes toward science and scientists between MBTI personality types.

This hypothesis was not rejected. The F-ratio of 0.29 for EI, 0.16 for SN, 0.01 for TF, and 1.20 for JP for Part I (attitudes toward science) scores of the SASAI were not significant. Likewise, the F-ratios of 0.15 for EI, 0.18 for SN, 0.09 for TF, and 0.04 for JP for Part II (attitudes toward scientists) scores of the SASAI were not significant.

Question 4: Is there any relationship between the attitudes toward science and scientists of eighth-grade science students and their intelligence?

Hypothesis 5: There is no statistically significant relationship between intelligence and attitudes toward science and scientists.

This hypothesis was rejected. The correlation coefficient of 0.21 for Part I (attitudes toward science) scores was significant. The correlation coefficient of 0.09 for Part II (attitudes toward scientists) scores of the SASAI was not significant.

Question 5: Do eighth-grade science students, classified according to their MBTI personality types and cognitive preference orientation, differ in science achievement?

Hypothesis 6: There is no statistically significant difference in mean science achievement scores between the MBTI personality types.

This hypothesis was not rejected. When the effects of intelligence were statistically removed by the analysis of covariance, differences in science achievement between the extravert (E) and introvert (I), between the sensing (S) and intuitive (N) students, between the thinking (T) and feeling (F) students, and between the judging (J) and perceiving (P) students could have occurred by chance alone. The F-ratios of 0.34 (EI), 0.10 (SN), 0.32 (TF), and 3.86 (JP) were not significant.

When the differences in science achievement between the MBTI personality type groups were examined, no significant differences were detected following the analysis of covariance between the SNTF type groups (ST, SF, NF, and NT) F-ratio = 0.28; or between the EISN type groups (IN, EN, IS, and ES) F-ratio = 0.16; or between the SNJP type groups (SJ, SP, NP, and NJ) F-ratio = 2.60.

Hypothesis 7: There is no statistically significant difference in mean science achievement scores between students classified according to their cognitive preference orientation.

This hypothesis was not rejected. The F-ratios of 1.69 (one preference classification - M, A, and Q) and 0.84 (two preference classification - MA, MQ, and AQ) were not significant.

Question 6: Is there any relationship between the science achievement of eighth-grade science students and their attitudes toward science and scientists?

Hypothesis 8: There is no statistically significant relationship between achievement scores in science and attitudes toward science and scientists.

This hypothesis was rejected. The correlation coefficients of 0.33 for Part I (attitudes toward science) scores and 0.23 for Part II (attitudes toward scientists) scores of the SASAI were both significant.

Question 7: Is there any relationship between the sex of eighth-grade science students and their MBTI personality types; cognitive preference orientation; or attitudes toward science and scientists?

Hypothesis 9: There is no statistically significant relationship between the MBTI personality types and sex of students.

This hypothesis was not rejected. The seven chi-square values obtained (EI - 9.55, SN - 1.02, TF - 3.66, JP - 0.27, SNTF - 4.70, EISN - 13.21, and SNJP - 1.64) were not significant.

Hypothesis 10: There is no statistically significant relationship between the cognitive preference orientation and sex of students.

This hypothesis was not rejected. The chi-square values of 0.36 (one preference classification - M, A, and Q) and 0.32 (two preference classification - MA, MQ, and AQ) were not significant.

Hypothesis 11: There is no statistically significant difference in attitudes toward science and scientists between males and females.

This hypothesis was not rejected. The F-ratios of 0.34 for Part I (attitudes toward science) scores and 0.007 for Part II (attitudes toward scientists) scores of the SASAI for the difference in means between males and females was not significant.

Question 8: Is there any relationship between the geographic area (urban, suburban, and rural) of eighth-grade science students and their MBTI personality types; cognitive preference orientation; and attitudes toward science and scientists?

Hypothesis 12: There is no statistically significant relationship between MBTI personality types and geographic area.

This hypothesis was not rejected. The seven chi-square values obtained (EI - 5.61, SN - 0.81, TF - 2.96, JP - 4.75, SNTF - 8.45, EISN - 13.28, and SNJP - 7.46) were not significant.

Hypothesis 13: There is no statistically significant relationship between cognitive preference orientation and geographic area.

This hypothesis was not rejected. The chi-square values of 5.55 (one preference classification - M, A, and Q) and 1.77 (two preference classification (MA, MQ, and AQ) were not significant.

Hypothesis 14: There is no statistically significant difference in attitudes toward science and scientists between students from urban, suburban, and rural geographic areas.

This hypothesis was not rejected. The F-ratios of 1.11 for Part I (attitudes toward science) scores and 4.45 for Part II (attitudes toward scientists) scores of the SASAI were not significant.

Conclusions

The conclusions drawn from this study are summarized according to: MBTI personality types, cognitive preference orientation, and attitudes toward science and scientists.

MBTI Personality Types

Six conclusions were reached when the relationships between the MBTI personality types of the eighth-grade science students in this study and the following variables were analyzed.

1. Cognitive preference orientation - No significant relationships could be detected between MBTI personality types and cognitive preference orientation. MBTI personality types are independent of cognitive preference orientation.

2. Attitudes toward science and scientists - There was no significant difference in attitudes toward science and scientists between the MBTI personality types.

3. Intelligence - Two significant findings were detected when intelligence and MBTI personality type was tested. Intuitive (N) students have higher intelligence scores than sensing (S) students. Perceiving (P) students have higher intelligence scores than judging (J) students. The eighth-grade science students in this study highest in intelligence are both intuitive (N) and perceiving (P); students lowest in intelligence are both sensing (S) and judging (J).

4. Science achievement - No significant differences in science achievement between the MBTI personality types could be detected after the effect of intelligence was statistically removed by the analysis of covariance. Observed differences in science achievement could be explained by intelligence rather than by MBTI personality types. It is suggested that intelligence of the students in this study is a more important factor for success in science than MBTI personality types.

5. Sex of students - No significant relationships between MBTI personality types and sex of students were found.

6. Geographic area - No significant relationships were found between MBTI personality types and students from urban, suburban, and rural geographic areas.

Cognitive Preference Orientation

Four conclusions were reached when the relationships between the cognitive preference orientation of the eighth-grade science students in this study and the following variables were analyzed.

1. Intelligence - There was no significant difference in intelligence between students classified according to their cognitive preference orientation.

2. Science achievement - There was no significant difference in science achievement scores between students classified according to their cognitive preference orientation.

3. Sex of students - No significant relationships between cognitive preference orientation and sex of students were found. Males and females in this study do not differ significantly in their cognitive preference orientation.

4. Geographic area. No significant relationships between cognitive preference orientation and geographic area were found. Students in urban, suburban, and rural geographic areas do not differ significantly in their cognitive preference orientation.

Attitudes Toward Science and Scientists

Four conclusions were reached when the relationships between attitudes toward science and scientists of the eighth-grade science students in this study were examined.

1. Intelligence - No significant relationship between intelligence and attitudes toward scientists was detected. The students in this study do not have significantly differing views toward scientists when intelligence is considered.

A significant relationship between intelligence and attitudes toward science was detected, however, It is suggested that the more intelligent students in this study may understand science better than they understand scientists.

2. Science achievement - Significant relationships between science achievement and attitudes toward science and scientists were detected. Students with higher achievement scores in science have more positive attitudes toward both science and scientists than students with lower intelligence scores.

3. Sex of students - There was no significant difference in attitudes toward science and scientists between the sexes. Males and females in this study

do not have significantly differing views toward science and scientists.

4. Geographic area - No significant differences in attitudes toward science and scientists were found between students from urban, suburban, and rural geographic areas. The students in this study from urban, suburban, and rural geographic areas have similar views toward science and scientists.

Discussion and Recommendations

The major premise of this study was that information gained from the Myers-Briggs Type Indicator, Cognitive Preference Examination-II, Science Knowledge Test and Science and Scientists Attitude Inventory could be used to help teachers and counselors assign students to science classes that are either inquiry-oriented (open, indirect teacher behaviors) or more traditional (fact-centered, direct teacher behaviors) in approach.

The assignment of students to particular classes and/or teachers might present difficulties in the practical school situation, especially with current trends such as heterogeneous grouping, elective classes and mainstreaming. Therefore, this writer hoped that information gained from the instruments could also be

used to better characterize the eighth-grade science students who participated in the study. A composite picture of these students was developed using the findings from the study.

All students who took the MBTI have an MBTI personality type by virtue of the nature of the test instrument. After scoring, it was found that:

a. there are slightly more extraverts (E) than introverts (I);

b. more students prefer to take information by sensing (S) than by intuition(N);

c. more students prefer to make judgments by feeling (F) than by thinking (T); and,

d. more students prefer an unstructured, perceiving (P) environment than a structured, judging (J) environment.

Intuitive (N) students are more intelligent than sensing (S) students and perceiving (P) students are more intelligent than judging (J) students. However, extraverts (E) and introverts (I), sensing (S), and intuitive (N) students, thinking (T), and feeling (F) students, and judging (J) and perceiving (P) students perform equally well in science. In addition, they do not have widely differing views of science and scientists.

Few students have a single detectable cognitive preference orientation at the eighth-grade level.

Most students (79.1%) are classified as having "no definite preference." Those students who do have a definite cognitive preference orientation: M - memory (5.0%), A - application (12.3%), Q - questioning (3.6%), perform equally well in science and are similar in intelligence.

Likewise, students classified according to two detectable preferences perform equally well in science and are similar in intelligence. Using a two preference classification, 17.3% have no detectable preference, 21.6% are AQ, 20.87% are MQ, and 40.3% are MA. It is suggested that the preference for memory responses in combination with application and questioning responses (61.1%) may result from the traditional expectations of students who are required to memorize information.

Although not part of this study, this writer did an informal analysis and found that students classified according to cognitive preference orientation do not have widely differing views of science and scientists.

Males and females in this study do not differ in their MBTI personality types, cognitive preference orientation, attitudes toward science and scientists, intelligence, and science achievement.

The students are equally similar when geographic area is examined. Students from urban, suburban and rural areas do not differ in their MBTI personality

types, cognitive preference orientation, attitudes toward science and scientists, intelligence and science achievement.

Students with higher achievement scores in science have more positive attitudes toward both science and scientists than students with lower achievement scores. It is suggested that students with higher achievement scores have more positive attitudes because they are successful in the subject.

When the relationship between intelligence and attitudes toward science and scientists was examined, students in this study did not have widely differing views toward scientists. However, students who are more intelligent have more positive attitudes toward science than students of lower intelligence. It is suggested that the intelligent student finds science to be easier than the less intelligent student but does not understand the nature and role of the scientist as well as the subject matter per se. This may be due to the fact that little emphasis is placed on the role of the scientist, his/her life, etc. in regular classroom instruction.

With these brief remarks in mind, the following recommendations are made for the teacher and counselor, and further research.

For the Teacher and Counselor

Although no significant relationships were demonstrated to exist between the cognitive preference orientation and MBTI personality types of the middle/junior high school students in this study, the information derived from the individual test instruments seems to be valuable for both the teacher and counselor. Since most decisions currently made concerning these students are based on the results of I.Q. tests (in schools which still use them), letter achievement grades and teacher/counselor recommendations, it is recommended that instruments such as the Myers-Briggs Type Indicator and cognitive preference tests be used to provide additional information to better characterize students. This information could be used in addition to those test instruments in current use by particular schools, teachers and counselors.

This information could help the classroom teacher to determine what instructional strategies would be most conducive for successful learning in science. Gagné (1970) recommends that the content of science be presented in discrete steps, from the basics to the concepts. Joseph Novak (1977), promulgating the Ausubelian viewpoint, suggests that the conceptual framework be presented before the basics. Perhaps the MBTI sensing types (S) (those who need facts and

prerequisite information), would be most comfortable with the former approach, whereas MBTI intuitive types (N) (those who are geared toward abstractions, generalizations and concepts, and are impatient with details) would be most comfortable with the latter approach.

Both the MBTI sensing types (S) and judging types (J) (those who need detailed plans and organization) would benefit from structured laborabory experiences. The MBTI intuitive types (N) and perceptive types (P) (those who prefer less-structured situations) would benefit from open-ended, inquiry-oriented laboratory experiences.

Myers (1962a) has indicated that individuals use both processes of a given function but prefer and trust one process over the other. Furthermore, the less-preferred process may be used and developed depending on the situation. It is the opinion of this writer that S and J students should be exposed to inquiry situations, albeit not exclusively. In this way, their intuitive and perceptive preferences may be further developed. This would require that the classroom teacher use different strategies within a given course of study.

Heath (1964) and others have suggested that the cognitive preference orientation of students may be influenced by curricular treatment. In essence, this

influence relies ultimately upon the teaching style adopted by the teacher. This writer postulates that three types of students may be identified within a particular classroom based on their cognitive preference orientation:

1. Traditionalists - These are students who exhibit either a strong memory (M) cognitive preference orientation or memory (M) in combination with application (A) and questioning (Q). These students prefer the recall of information, enjoy memory work and may resist an inquiry approach. They may be served best by a traditional approach to science teaching, the way most teachers do teach.

2. Natural Inquiers - These are students who exhibit a questioning (Q) and application (A) cognitive preference orientation. These students may already be "inquiry-minded" and find inquiry approaches to be the natural way to learn. They may also find traditional approaches somewhat tedious.

3. Undecided - These are students who do not exhibit a particular cognitive preference orientation. As in this study, these students are probably in the majority in most classrooms. It is these students who are the most influenced by a particular curriculum

program and teaching style associated with it. This writer suggests that these students may become inquirers if they are taught by a teacher who is inquiry-oriented (open, indirect teacher behavior). These same students may also be influenced by a traditional teaching approach (fact-centered, direct teaching behavior).

If one of the goals of science education is to produce inquiry-oriented citizens, then teachers should examine their own learning and instructional biases, which may be influenced by their MBTI personality type and cognitive preference orientation. One would not expect to see the development of inquiry skills in students if they are taught by a teacher who is highly sensing and judging or exhibits a strong preference for the recall of specific facts.

With these brief comments, this writer makes the following general recommendations for the teacher and counselor:

1. Time should be provided to give tests such as the Myers-Briggs Type Indicator and cognitive preference tests to junior high/middle school students to provide additional information as to their particular learning preferences.

2. Teachers should provide for these particular learning preferences by using multiple instructional

strategies within a given classroom situation. These could include, but not be limited to, open-ended laboratories, discovery approaches, programmed instruction, small group work, and independent work.

3. Counselors could use this information to anticipate problems that certain students might have with a particular course or teacher. An inquiry course may not be recommended if it is known that a student is highly sensing and exhibits a preference for the memorization of specific facts. Likewise, a course of study requiring extensive use of detailed information would not be recommended for a student who lacks patience with details.

4. Teachers should take tests such as the Myers-Briggs Type Indicator and cognitive preference tests. The particular preferences of the teacher may not be congruent with the preferences of students. A teacher who is highly intuitive may relate well with intuitive students but lose patience with students who are sensing. By recognizing his intuitive nature, the teacher may adjust his instructional strategies to include those strategies specific for sensing students within the class.

5. Males and femals did not differ significantly from each other on most measures in this study.

Therefore, it is recommended that boys and girls receive the same science instruction and encouragement to consider science as a career.

6. Teachers should incorporate specific learnings about attitudes toward science and scientists into their plans. If instructional strategies are altered to meet the needs of individual students, their success may then be associated with the development of positive attitudes toward science. Perhaps seeing a scientist as a person (without the lab coat) might be one step in the direction of developing a positive attitude toward scientists.

For the Researcher in Science Education

The following recommendations for further study are made for the researcher in science education:

1. Studies should be conducted centering on the majority of students who do not exhibit a definite cognitive preference orientation, in particular, on the factors which may influence the development of particular preferences. This writer performed most of the statistical analyses using the "no detectable preference" group. However, the results of the analyses were not significantly different from those resulting using only distinct preferences, i.e., M, A, Q, or

MA, MQ, AQ.

2. A discipline-free cognitive preference test should be developed for use by junior high/middle school students similar to the CPE-II.

3. The influence of the teacher's personality type, cognitive preference orientation and teaching style has been mentioned in this study. The relationships between these variables and student personality types, cognitive preference orientation and learning styles should be investigated.

4. Studies should be conducted to determine if any relationships exist between SN and JP MBTI personality types and concrete vs. formal thinking.

5. Studies of this type should be conducted with the "older" student. Many community colleges have open-door policies. Students select courses or programs of study with little or no regard for factors other than interest. This writer has found in an informal study that most community college students are highly sensing and judging and find difficulty with traditional college teaching strategies.

Myers (1962a) has indicated that the MBTI might help individuals "... who find rough sledding" in various areas of concern. It was the intention of this

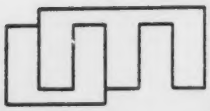
writer that this study help students "... who find rough sledding... " in today's science classes. If this study does nothing more than make one teacher realize that students in a particular class may be different from each other in terms of their learning preferences, then this writer's objectives have been met. If this same teacher modifies his instructional strategies to accommodate these students in terms of their differences, with the result that they not only succeed but develop a positive attitude toward science, objectives nothwithstanding, this writer would then consider the study to be a success.

APPENDIX

APPENDIX A

Letter Describing the Study

and Informed Consent Form



THE UNIVERSITY OF MICHIGAN

School of Education
Corner East and South University Avenues
Ann Arbor, Michigan 48109

Dear Parent or Guardian:

Your child is in a class which as been selected to participate in a research study I am conducting at The University of Michigan, School of Education, as part of my doctoral dissertation in Secondary Science Education.

Many educators and parents are aware of the increasing importance of science and technology in today's world. For this reason, students are being encouraged by teachers, counselors, and parents to take science not only during junior high school but also as part of their senior high school program.

However, we find that many students do not like their high school science classes or find the subject matter difficult with the result that they lose interest, do not elect to take additional classes and recall science in their adult lives with distaste. Perhaps this is through no fault of their own.

Placement in senior high school programs usually depends on a student's achievement grade in science or teacher/counselor recommendations with little concern for other factors. The main thrust of my research study is to examine certain factors which might be used by teachers and counselors to place students in senior high school classes such that they not only will succeed but also will find the subject matter challenging but not beyond their capability. Furthermore, they may tend to develop a more positive attitude toward science and become a truly scientifically literate citizen.

The factors that I have selected to examine are personality type, attitude toward science and scientists and learning style. In order to measure these characteristics, your child will be asked to complete three forms and to take one short science knowledge test. This will involve approximately 2¼ class periods. In addition, the grade your child receives in science and a reading score will be provided from school records. All forms and tests will be coded and any identifying information will be removed. None of the materials in any form except final group results will be available to university or school personnel.

If you are willing to allow your child to participate in this study, would you please sign the attached informed consent form and have your child return it to his/her science teacher by _____. Non-participation will in no way modify the educational services provided for your child. Thank you for your cooperation. If you have any questions do not hesitate to call me at (313) 764-8402.

It goes without saying that you are not obligated to give your consent and may withdraw it if you wish at any time.

Sincerely,

John A. Novak

John A. Novak

Informed Consent Form

The research project to be conducted by John A. Novak of The University of Michigan's School of Education as a doctoral dissertation has been explained to me. I understand that my participation is completely voluntary. Further, I understand that if I agree to participate, I will fill out the following items:

1. Myers-Briggs Type Indicator personality inventory
2. Cognitive Preference Examination II
3. Science and Scientists Attitude Inventory
4. Science Knowledge Test

I further understand that: All information is confidential and coded. I am free to withdraw my consent and to discontinue my participation in the project at any time. Any questions I have about the project will be answered.

On the basis of the above statements:

____ I agree to participate in this project.

____ I do not wish to participate in this project.

_____ John A. Novak

Student's signature

Investigator's signature

John A. Novak
1225 School of Education
The University of Michigan
Ann Arbor, Michigan 48109
Phone: (313) 764-8402

_____

Parent/Guardian's signature

_____

Date

APPENDIX B

Science Knowledge Test

Science Knowledge Test

INSTRUCTIONS:

Please answer each of the following questions by placing the letter of the correct answer on the answer sheet.

If you do not know the answer to any question, leave it blank.

Look at the following example:

EXAMPLE

In science, one is LEAST likely to do which of the following things with an apple?

a. weigh it
b. measure its size
c. describe its color
d. write a poem about it
e. find how many seeds it has

a	b	c	d	e
═	═	═	═	═

Since the correct answer is letter d, you would completely darken in the space below letter d. If you did not know the answer, you would have left this one blank.

NOTE: Please do not write on the question sheet. Use the pencil provided. Remember to leave an answer blank if you do not know the answer.

1. Most of the Earth's surface is:

   a. cities and towns
   b. farm land
   c. solid rock
   d. water
   e. yellow

2. An average serving of which of the following foods would provide the most protein for building and repairing the body tissues:

   a. boiled potatoes
   b. green beans
   c. lean meat
   d. oatmeal
   e. white bread

3. What is needed to move cars, heat hamburgers and light rooms?

   a. efficiency
   b. energy
   c. conservation
   d. friction
   e. magnetism

4. The only star you usually see in the daytime is:

   a. Venus
   b. the Sun
   c. the Moon
   d. the Pole Star
   e. Alpha Centauri

5. When one sees a powder made up of both white and black specks, one is able to conclude that he has:

   a. sugar
   b. pepper
   c. a mixture
   d. an element
   e. a pure compound

6. How do we get scientific laws?

   a. scientists vote on them
   b. they are made by the police
   c. they are passed by Congress
   d. they come from many experiments

7. Fanning can make a campfire burn better because fanning:

   a. raises the atmospheric pressure
   b. warms materials to their kindling points
   c. increases the supply of material that can burn
   d. increases the supply of oxygen for the burning
   e. provides the energy needed to keep the fire going

8. Which of the following is an opinion rather than a fact about cats?

   a. cats eat mice
   b. cats have fur
   c. cats have tails
   d. cats are related to tigers
   e. Siamese cats are prettier than other cats

9. A boy notices that water puddles of the same size last longer in winter than in summer. Which of the following is the best explanation?

   a. water evaporates faster on hot days
   b. cold water is thick and doesn't run very quickly
   c. water can sink into the ground only in winter
   d. there are fewer winds in summer to interfere with drying up puddles
   e. the heat of the summer sun changes water to hydrogen and oxygen gases

10. To determine the average height of 13-year-olds, it would be most important to have a large number of:

   a. scales
   b. yardsticks
   c. 13-year-olds
   d. people doing the measuring
   e. observers of each measurement

11. John has a flat tire on his bicycle. He pumps the tire with an air pump and begins to ride. In a few minutes the tire is flat again. To fix his tire, John must find:

   a. a better air pump
   b. whether the tire is made of rubber
   c. where the air leaks out of the tire
   d. how many minutes it takes the tire to go flat

12. When a person sees something, what carries the message from the eyes to the brain?

a. arteries
b. glands
c. muscles
d. nerves
e. veins

13. Seeds come from which of the following parts of a plant?

a. bark
b. flower
c. leaf
d. root
e. stem

14. What does an electric power company sell in units of kilowatt-hours?

a. atoms
b. electrons
c. energy
d. radiation
e. time

15. The time it takes the Moon to go from new moon to full moon and back to new moon is about

a. 1/2 day
b. 1 day
c. 14 days
d. 28 days
e. 365 days

16. From which of these can all kinds of matter be formed?

a. atoms
b. compounds
c. mixtures
d. protons

17. Which of the following helps to account for the fact that a compass can be used to find north on Earth?

a. Earth has only one moon
b. Earth has a magnetic field
c. Earth reflects the Sun's light
d. Most of Earth is covered by water
e. Earth's temperature is not constant

18. A doctor kept records of breathing rates of people when they were resting. He made the chart below.

BREATHING RATES

Person	Breaths in a Minute
Baby boys	38
7-year-old girls	25
7-year-old boys	25
10-year-old boys	20
Mothers	16

The chart suggests that:

a. boys breathe faster than girls
b. girls breathe faster than boys
c. older people breathe faster than younger people
d. younger people breathe faster than older people

19. What is the most important thing that the lungs do?

a. hold the chest out
b. protect against germs
c. move different parts of the body
d. pump the blood through the body
e. provide a place for oxygen to enter the body

20. Green plants are important to animals because the plants:

a. consume both food and oxygen
b. consume food and give off oxygen
c. consume food and give off dioxide
d. produce food and give off oxygen
e. produce food and give off carbon dioxide

APPENDIX C

Myers-Briggs Type Indicator

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APPENDIX C PAGES 190-197 "MYERS-BRIGGS TYPE INDICATOR"
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APPENDIX D

Cognitive Preference Examination II

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APPENDIX E

Science and Scientist Attitude Inventory

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APPENDIX E PAGES 207-210 "SCIENCE AND SCIENTIST ATTITUDE INVENTORY" REMOVED DUE TO COPYRIGHT RESTRICTIONS.

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